THEME [FoF-ICT-2011.7.1]
[Smart Factories: Energy-aware, agile manufacturing and customisation]

Grant agreement for: Collaborative project*

Annex I - "Description of Work"

Project acronym: ARUM

Project full title: " ADAPTIVE PRODUCTION MANAGEMENT "

Grant agreement no: 314056

Version date: 2013-07-18

Table of Contents

Part A

Workplan Tables

A1:
Project summary

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per project

General information			
Project title [3]	ADAPTIVE PRODUCTION MANAGEMENT		
Starting date [4]	01/09/2012		
Duration in months [5]	37		
Call (part) identifier [6]	FP7-2012-NMP-ICT-FoF		
Activity code(s) most relevant to your topic [7]	FoF-ICT-2011.7.1: Smart Factories: Energy-aware, agile manufacturing and customisation		

Abstract [9]

The production and ramp-up of complex and highly customized products are exceptionally challenging for planning and control, especially in small lot sizes. Daily challenges like late requests for change, immature high technology products and processes create significant risks. The occurring risks are bigger than production of big series such as automotive. Thus, new ICT-based approaches are required. The aim is to develop mitigation strategies to respond faster to unexpected events. Therefore the knowledge base has to be enriched for real-time decision support, to detect early warning and to accelerate learning. Our approach is based on a new generation of service orientated enterprise information platforms, a service orientated bus integrating service-based architecture and knowledge-based multi-agent systems (MAS). A holonic MAS combined with a service architecture will improve performance and scalability beyond the state of the art. The solution integrates multiple layers of sensors, legacy systems and agent-based tools for beneficial services like learning, quality, risk and cost management. Additionally the ecological footprints will be reduced. The ARUM solution will run in two modes: predictive and real time simulation. The predictive mode supports the planning phase whereas the real-time operations mode supports dynamic, time-, cost- and risk-oriented re-planning of operations. The provision of information for engineering to alter in case of immaturity or late requests for changes is supported equally. ARUM is strongly end-user driven and the results will be tested on three industrial use cases with a focus on aircraft, aircraft interiors and ship manufacturing. The solution will be validated in a real industrial environment by industrial partners and benchmarked against today's ICT solutions. In collaboration with universities a test-bed will be established for design and testing of ARUM systems and tools and will be opened for dissemination and demonstration.

A2:
List of Beneficiaries

Project Number [1]	314056	Project Acronym [2]	ARUM

List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
1	EADS DEUTSCHLAND GMBH	EADS	Germany	1	37
2	AIRBUS OPERATIONS GMBH	AIB	Germany	1	37
3	CERTICON A.S	CER	Czech Republic	1	37
4	MGS MODULAR GALLEY SYSTEMS AG	MGS	Germany	1	37
5	TIE NEDERLAND B.V.	TIE	Netherlands	1	37
6	SEC SMART SOLUTIONS	SMRT	Russian Federation	1	37
7	ALMENDE B.V.	ALM	Netherlands	1	37
8	Fachhochschule Köln	CUAS	Germany	1	37
9	P3 INGENIEURS SAS	P3	France	1	37
10	THE UNIVERSITY OF MANCHESTER	UNIMAN	United Kingdom	1	37
11	Instituto Politécnico de Bragança	IPB	Portugal	1	37
12	INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS	ICCS	Greece	1	37
13	CESKE VYSOKE UCENI TECHNICKE V PRAZE	CTU	Czech Republic	1	37
14	FERNUNIVERSITAET IN HAGEN	UNIHA	Germany	1	37

A3:
Budget Breakdown

Project Number [1]	314056	Project Acronym [2]	ARUM

One Form per Project

Participant number in this project [11]	Participant short name	Fund. % [12]	Ind. costs [13]	Estimated eligible costs (whole duration of the project)					Requested EU contribution
				RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total A+B+C+D	
1	EADS	50.0	A	938,681.00	172,896.00	379,546.00	155,167.00	1,646,290.00	1,089,501.00
2	AIB	50.0	A	242,543.00	93,719.00	0.00	109,146.00	445,408.00	277,276.00
3	CER	75.0	T	1,283,835.00	64,176.00	6,000.00	124,448.00	1,478,459.00	1,125,412.00
4	MGS	75.0	F	398,710.00	109,202.00	3,000.00	141,081.00	651,993.00	402,710.00
5	TIE	75.0	A	886,722.00	93,324.00	16,000.00	251,328.00	1,247,374.00	964,024.00
6	SMRT	75.0	T	628,000.00	44,400.00	6,000.00	99,200.00	777,600.00	598,400.00
7	ALM	75.0	T	674,400.00	111,200.00	7,500.00	98,400.00	891,500.00	667,300.00
8	CUAS	75.0	T	431,200.00	73,600.00	3,000.00	112,800.00	620,600.00	476,000.00
9	P3	50.0	F	687,408.00	106,512.00	3,000.00	37,404.00	834,324.00	437,364.00
10	UNIMAN	75.0	T	679,664.00	11,152.00	3,000.00	177,728.00	871,544.00	696,052.00
11	IPB	75.0	T	346,880.00	23,680.00	0.00	84,320.00	454,880.00	356,320.00
12	ICCS	75.0	T	457,280.00	56,000.00	3,000.00	167,680.00	683,960.00	541,640.00
13	CTU	75.0	T	430,400.00	21,920.00	3,000.00	53,920.00	509,240.00	390,680.00
14	UNIHA	75.0	T	525,440.00	60,800.00	3,000.00	39,520.00	628,760.00	467,000.00
Total				8,611,163.00	1,042,581.00	436,046.00	1,652,142.00	11,741,932.00	8,489,679.00

Note that the budget mentioned in this table is the total budget requested by the Beneficiary and associated Third Parties.

*** The following funding schemes are distinguished**

Collaborative Project (if a distinction is made in the call please state which type of Collaborative project is referred to: (i) Small of medium-scale focused research project, (ii) Large-scale integrating project, (iii) Project targeted to special groups such as SMEs and other smaller actors), Network of Excellence, Coordination Action, Support Action.

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project, and it cannot be changed. The project number **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

2. Project acronym

Use the project acronym as indicated in the submitted proposal. It cannot be changed, unless agreed during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry info force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a detailed justification on a separate note.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Activity code

Select the activity code from the drop-down menu.

8. Free keywords

Use the free keywords from your original proposal; changes and additions are possible.

9. Abstract

10. The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

11. The number allocated by the Consortium to the participant for this project.

12. Include the funding % for RTD/Innovation – either 50% or 75%

13. Indirect cost model

A: Actual Costs
S: Actual Costs Simplified Method
T: Transitional Flat rate
F :Flat Rate

Workplan Tables

Project number

314056

Project title

ARUM—ADAPTIVE PRODUCTION MANAGEMENT

Call (part) identifier

FP7-2012-NMP-ICT-FoF

Funding scheme

Collaborative project

WT1
List of work packages

Project Number [1]	314056	Project Acronym [2]	ARUM

LIST OF WORK PACKAGES (WP)

WP Number [53]	WP Title	Type of activity [54]	Lead beneficiary number [55]	Person-months [56]	Start month [57]	End month [58]
WP 1	End-user requirements	RTD	2	76.00	1	37
WP 2	Use Cases	RTD	1	117.00	1	28
WP 3	Ramp-up & Production Strategies	RTD	9	76.00	1	28
WP 4	System Architecture and Interfaces	RTD	10	236.00	6	28
WP 5	Methods & Tools for Adaptive Planning, Scheduling, and Optimization	RTD	3	282.00	6	28
WP 6	Integration	RTD	5	82.00	13	37
WP 7	Trials, Assessment & Validation	DEM	1	106.00	23	37
WP 8	Show cases	OTHER	4	37.00	31	37
WP 9	Exploitation, Standardisation & Dissemination	OTHER	12	107.00	1	37
WP 10	Overall project management	MGT	1	22.00	1	37
			Total	1,141.00		

WT2:
List of Deliverables

Project Number [1]	314056	Project Acronym [2]	ARUM

List of Deliverables - to be submitted for review to EC

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1.1	Benchmarking of different industrial production systems	1	9	16.00	R	PU	7
D1.2.2	Analysis of Production Systems of Industry Partners	1	2	21.00	R	RE	7
D1.3.1	ARUM requirements management solution	1	1	3.00	O	CO	4
D1.3.2	End-user & ARUM industrial scenario Requirements first revision	1	1	18.00	R	RE	7
D1.3.3	End-user & ARUM industrial scenario Requirements final revision	1	1	6.00	R	RE	28
D1.3.4	ARUM Requirements Validation Report	1	1	7.00	R	RE	37
D1.3.5	Concept for simulation and real process data integration into the production workflow	1	1	5.00	R	RE	13
D2.1.1	Use-Case Definition (use cases #1 & #2)	2	1	14.00	R	RE	7
D2.1.2	Use-Case Definition (use case #3)	2	1	8.00	R	RE	13
D2.2.1	Use-Case Detailing and KPI setting	2	9	27.00	R	RE	13

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D2.3.1	Use-Cases #1: Implementation (new product ramp-up)	2	2	30.00	O	RE	28
D2.4.1	Use-Cases #2: Implementation (Small lot production #1)	2	4	23.00	O	RE	28
D2.5.1	Use-Cases #3: Implementation (Small lot production #2)	2	1	15.00	O	RE	28
D3.1.1	Best Practice Ramp-up & Small Lot Production Strategies	3	9	26.00	R	PU	9
D3.2.1	Beneficial ARUM Business Strategies (1st release)	3	9	9.00	R	RE	19
D3.2.2	Beneficial ARUM Business Strategies (2nd release)	3	9	10.00	R	RE	25
D3.2.3	Beneficial ARUM Business Strategies (final release)	3	9	10.00	R	RE	28
D3.3.1	SoA and selection of OMT	3	8	5.00	R	RE	7
D3.3.2	ARUM Ontology version-1	3	8	8.00	O	RE	13
D3.3.3	Learning-curve Strategy	3	8	8.00	R	RE	19
D4.1.1	SoA and System Architecture and Platform Specifications 1st draft	4	10	20.00	R	RE	13
D4.1.2	System Architecture and Platform Specifications	4	10	19.00	R	RE	15
D4.2.1	First prototype of iESB	4	3	68.00	P	RE	19

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	components and P2P agents layer						
D4.3.1	Legacy System Integration Specifications and Components (1st release)	4	5	12.00	P	RE	19
D4.3.2	Legacy System Integration Specifications and Components (2nd release)	4	5	22.00	P	RE	25
D4.3.3	Legacy System Integration Specifications and Components (final release)	4	5	12.00	P	RE	28
D4.4.1	iESB platform and guides (user and programmer)	4	3	83.00	P	RE	28
D5.1.1	Methods and tools specifications	5	3	32.00	R	RE	13
D5.1.2	Concept of knowledge management tools integration into engineering process of WP5	5	3	10.00	R	RE	7
D5.2.1	Factory Network and Scenario Designer (1st release)	5	8	22.00	P	RE	19
D5.2.2	Factory Network and Scenario Designer (2nd release)	5	8	22.00	P	RE	25
D5.2.3	Factory Network and Scenario Designer (final release)	5	8	23.00	P	RE	28
D5.3.1	Strategic Planning and	5	3	23.00	P	RE	19

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	Optimization Tool (1st release)						
D5.3.2	Strategic Planning and Optimization Tool (2nd release)	5	3	23.00	P	RE	25
D5.3.3	Strategic Planning and Optimization Tool (final release)	5	3	22.00	P	RE	28
D5.4.1	Tactical and Operational Planning, Scheduling and Optimization Tool (1st release)	5	6	35.00	P	RE	19
D5.4.2	Tactical and Operational Planning, Scheduling and Optimization Tool (2nd release)	5	6	35.00	P	RE	25
D5.4.3	Tactical and Operational Planning, Scheduling and Optimization Tool (final release)	5	6	35.00	P	RE	28
D6.1.1	ARUM Integration Testbed ready for Integration	6	5	33.00	O	RE	23
D6.2.1	Overall System Integration first release	6	5	24.00	P	RE	28
D6.2.2	Overall System Integration & Verification	6	5	25.00	P	RE	31
D7.1.1	ARUM trials planning	7	1	6.00	R	RE	25
D7.1.2	ARUM Trials	7	1	28.00	R	RE	34

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D7.2.1	Assessment of Operational, Ecological, Economical Effects	7	9	30.00	R	RE	37
D7.3.1	Benchmark of ARUM approach	7	14	42.00	R	RE	37
D8.1.1	Show cases planning	8	4	6.00	R	PP	34
D8.1.2	Show cases report	8	4	18.00	R	PP	37
D8.2.1	End-User Validation	8	1	13.00	R	RE	37
D9.1.1	Dissemination and Collaboration plan	9	5	8.00	R	RE	7
D9.1.2	Project web page, project description, leaflet, use case brochure, poster and project slide show	9	5	10.00	O	PU	13
D9.1.3	Dissemination Status and Content	9	5	10.00	R	RE	25
D9.1.4	Dissemination Status and Content	9	5	9.00	R	RE	37
D9.1.5	Living lab strategy	9	12	3.00	R	RE	13
D9.1.6	Living lab	9	12	6.00	O	PU	37
D9.1.7	Final ARUM dissemination workshop scope and objectives plan	9	12	2.00	R	RE	25
D9.2.1	Standardisation	9	12	19.00	R	PU	37
D9.3.1	End-User Training	9	2	19.00	R	PP	37
D9.4.1	IPR Specification Report and Exploitation Plan	9	1	7.00	R	RE	13

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D9.4.2	Intermediate Exploitation Report	9	1	7.00	R	RE	25
D9.4.3	Final Exploitation Report	9	1	7.00	R	RE	37
D10.1.1	Project Management Plan	10	1	1.00	R	CO	1
D10.1.2	EAB candidate list	10	1	1.00	O	CO	7
D10.1.3	EAB and ToR are established	10	1	2.00	O	CO	12
D10.1.4	Management report n°1	10	1	6.00	R	CO	13
D10.1.5	Management report n°2	10	1	6.00	R	CO	25
D10.1.6	Management final report	10	1	6.00	R	CO	37
			Total	1,141.00			

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP1	Type of activity [54]	RTD
Work package title	End-user requirements		
Start month	1		
End month	37		
Lead beneficiary number [55]	2		

Objectives

The objective of WP1 is to define the end-user requirements in terms of improving production performance. Therefore the first step is to compare the actual ramp-up performance of the industrial partners with best practice companies. Hereby best practices in Information and Communication Technologies (ICT), automation technologies and management systems are identified which increase the performance of production systems. Flexibility, robustness and rapid learning are key enabler in small lot production and frequent ramp-up industries. These strategies are additionally benchmarked. Afterwards the gap between industrial partners and best practise of today´s production and production management systems is determined. Finally requirements from end-users for the ARUM framework will be derived to achieve future production targets.
The WP 1 will manage the ARUM requirements (end-user requirements from WP1 and further detailed requirements like functional and system requirements from WP 3, 4, 5) along the complete ARUM project and will support all ARUM WP with tool-based management functions needed for requirements derivation, tracking and validation.

Description of work and role of partners

Task 1.1. Benchmarking of different industrial production systems (Lead: P3)
Task 1.1 compares the actual ramp-up performance of partners with best practise of industrial competitors.

Content of work:
• To provide basic training to all ARUM partners in Aerospace ramp-up processes using business game based workshops.
• To conduct an As-Is analysis of involved industry partners. Identification and assessment of occurring risks within risk management framework.
• To select and define ramp-up/production Key Performance Indicators (KPI). This contributes also to Task 2.2
• Identify all indicators for benchmark
• After finishing the As-Is analysis of industrial partners a benchmark analysis of industrial production systems is conducted. The benchmark considers companies of highly customized and complex products exposed to a highly dynamic environment concerning ramp-up and small series production. For the benchmark we do not only consider direct competitors but also best-in-class companies from other branches.
• To benchmark the performance and production technologies of different industrial production systems.
• Furthermore key Information and Communication Technologies (ICT) and automation technologies and management systems which support the performance are identified and finally included in the benchmark.

Task 1.2 Gap Analysis of Production Systems of Industry Partners (Lead: AIB)
Task 1.2 determines the gap between best practice of today's production and production management systems and the selected use cases (incl. Ramp-up management).

Content of work:
• The results of the As-Is analysis of the industrial partners are used to carry out a Strengths, Weaknesses, Opportunities, and Threats analysis (SWOT)
• To conduct a To-Be analysis in order to define target KPIs and overall objectives for the use-cases. Therefore use the results of SWOT analysis. Additionally further requirements of future products are identified and integrated into the To-Be analysis.

• To perform a gap analysis of best practise companies and partners. Based on the To-Be analysis of the use-cases the performance gap to the benchmarked industries is determined.

Task 1.3 End-user & ARUM industrial scenario Requirements (Lead: EADS)
Task 1.3 gather the ARUM end-user requirements and support the requirements management across the ARUM project and for all other WPs. The requirements shall reflect also the specific constraints and the state-of-play of production scenarios (e.g. existing Airbus digital shop floor information systems) and how the end-users (shop floor workers) to be exposed to the ARUM solution (e.g. training, assembly support, feedback, human machine interface, etc.).

Content of work (end-user requirements gathering):
• To derive from the benchmark analysis of industrial competitors and the To-Be-analysis of use-cases the final end-user requirements for an ARUM Framework. This includes also the identification of technologies supporting the overall performance.
• Derivation of ICT requirements for ARUM framework. Therefore requirements of stakeholder using the ICT need to be stated, e.g. graphical user interface, selection of data, etc.
• To determine performance and functional requirements of ICT, e.g. response time, data volume, supporting functions, etc.
• To derive the industrial environment requirements, e.g. legacy systems, means of communication.
• Set up typical production scenarios. Therefore the production plans of use-cases of the past and the future are analysed and typical scenarios derived.
• To detail for the envisaged industrial scenarios the types of sensor data to be gathered to monitor in real time the actual production status and how the feedback is provided by shop floor workers to product designers
• to further detail a viable concept for simulation and real process data integration into the production workflow, specifically providing the requirement specifications for timeliness and user interfaces in WP5

The requirements gathering will be supported by use of an existing basic version of real time scheduler (provided by SRMT) for selected typical workshops with more or less simple product and assembling process consisting of about a hundred parts, each part requires about 20-30 operations. It will immediately give first view on what must be customized for selected use-cases and chance to start getting user feedback and end-user requirements, tuning of scheduling logic and integration. It will show benefits and peculiarities of real time adaptive scheduling.
Content of work (ARUM requirements management):
• To manage the ARUM requirements along the complete ARUM project in a central requirements repository (tool-supported storage, tracking and validation)
• To provide tool-based functions (e.g. using DOORS) to all ARUM work packages for requirements definition, tracking and validation
• To administrate the requirements repository / requirements management tool along the ARUM project

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	11.00
2	AIB	8.00
3	CER	2.00
4	MGS	6.00
5	TIE	6.00
6	SMRT	9.00
7	ALM	3.00
8	CUAS	4.00
9	P3	15.00
10	UNIMAN	3.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
11	IPB	2.00
12	ICCS	2.00
13	CTU	3.00
14	UNIHA	2.00
	Total	76.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1.1	Benchmarking of different industrial production systems	9	16.00	R	PU	7
D1.2.2	Analysis of Production Systems of Industry Partners	2	21.00	R	RE	7
D1.3.1	ARUM requirements management solution	1	3.00	O	CO	4
D1.3.2	End-user & ARUM industrial scenario Requirements first revision	1	18.00	R	RE	7
D1.3.3	End-user & ARUM industrial scenario Requirements final revision	1	6.00	R	RE	28
D1.3.4	ARUM Requirements Validation Report	1	7.00	R	RE	37
D1.3.5	Concept for simulation and real process data integration into the production workflow	1	5.00	R	RE	13
		Total	76.00			

Description of deliverables

D1.1.1) Benchmarking of different industrial production systems: Report of the benchmarking results of different industrial production systems [month 7]

D1.2.2) Analysis of Production Systems of Industry Partners: Report of an analysis of existing production systems of the industry partners within ARUM [month 7]

D1.3.1) ARUM requirements management solution: The ARUM requirements management toolset (e.g. Doors) is available for all ARUM partners [month 4]

D1.3.2) End-user & ARUM industrial scenario Requirements first revision: Report of the end-user requirements, first release stored and managed in ARUM requirements toolset and starting point for continues update [month 7]

D1.3.3) End-user & ARUM industrial scenario Requirements final revision: Update and final release of D1.3-2 Report of the end-user requirements as reflected in final releases of WP3 final business strategies and WP4 and WP5 software releases. [month 28]

D1.3.4) ARUM Requirements Validation Report: Final report of validation the ARUM solution against all requirements defined and managed in the ARUM requirements management toolset (end-user, functional and system requirements) [month 37]

D1.3.5) Concept for simulation and real process data integration into the production workflow: The report shall detail the approach of the project on what type of sensor data will be gathered to monitor in real time the actual production status and how feedback is provided by shop floor workers to product designers. It shall further detail a viable concept for simulation and real process data integration into the production workflow, specifically providing the requirement specifications for timeliness and user interfaces in WP5. [month 13]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS1	ARUM requirements management established	1	4	Requirements management software selected and available to all partners
MS2	End-user requirements defined	1	7	Availability of requirements and use case definition
MS13	ARUM requirements finalized	1	28	end-user requirements document final release available

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP2	Type of activity [54]	RTD
Work package title	Use Cases		
Start month	1		
End month	28		
Lead beneficiary number [55]	1		

Objectives

The WP 2 objective is to define, model and implement the industrial use-cases the ARUM solution is built for and will validated against. The defined use cases will drive the development of business strategies in WP 3 and technical solutions in WP 4 and WP 5 and form the main axis for their validation and demonstration in WP 7 and WP8. For that reasons the use cases definition includes the definition of key performance indicators for benchmarking and assessments the quantitative ARUM targets (see Part B) in WP7.
Two use cases will address vertical and horizontal integrated planning and control for the ramp-up phase. Both use cases will be developed as a field trail in a real industrial environment in WP7. A third use case shall be elaborate to prove the applicability of the ARUM architecture to other sectors like ship yards or automotive. The scope and complexity of the third use case will be defined until end of 1st year (e.g. case study).
WP 2 has to identify the scope for each use case and has to detail and formal model it and to define the KPI settings. The use case implementation shall include discrete-event simulation (stimulus) models to run at the ARUM test bed and the provision of data sets from industrial partners. All use cases will be deployed to WP7 and integrated at ARUM testbed for ARUM validation and benchmarking.

Description of work and role of partners

Task 2.1 Use-Case Definition (Lead: EADS)
To define the uses-cases in order to model industrial scenarios used for trials in real industrial environment. This task is executed for the two use cases addressing the vertical and horizontal integrated planning and control for the ramp-up phase at Airbus and MGS.

For the third use case (prove of applicability of the ARUM architecture to other sectors) the scope and complexity has to be defined first.

Content of work:
• Translation of end-user & industrial scenario requirements into use cases
• Definition of scope of Ramp-up & Small lot production use cases:
o Time: length of consideration, number of examples, length of series
o Stakeholder connected to production system
o Selection of considered production elements: number of production stations, steering elements
o Product analysis: variation, complexity, stakeholder
o Workflow analysis
o Data analysis of legacy system
o Determine level of aggregation for product, process and data
• Analysis of Ramp-up & Small lot production use cases
o Determine relations between elements
o Data flow analysis
• Define required interfaces and exchange data needed for use case execution
• Define the simple use case to run from the very beginning on the basic prototype installed for better collecting end-user requirements, customizing existing tools and benchmarking and demonstration of first early results (Month 3).
• To define the scope and complexity of third use case (prove the applicability of the ARUM architecture to other sectors)

Task 2.2 Use-Case Detailing and KPI setting (Lead: P3)
To detail the use-case and defines KPI setting in the use cases for performance assessment.

Content of work:
• Identification of methods to describe the production system, e.g. UML, Petri Nets
• Formal description (modeling) of production systems (relevant elements)
• Selection, collection and analysis of required data (WP 1)
• Risk analysis, Cause-impact analysis
• Definition of risk management approaches (WP 3)
• Selection of Business strategies (WP 3)
• To identify KPIs for benchmark and validation

Task 2.3 Use-Case #1: Implementation – new product ramp-up (Lead: AIB)
Use case #1 implements the new aircraft type production ramp-up use-case in stimulus models based on discrete event simulation model. This use case addresses mainly the vertical integration of planning and control for the ramp-up phase. The models will be used for the trails and the benchmark of ARUM approach in task 7.3.

Content of work:
• Set up a production model for the use-case, validate and verify the corresponding simulation models
• Definition of interfaces to legacy system
• Integration of required legacy systems by interfaces or via real data samples
• Simulation of use-case in real-time environment with selected risks
• Application of business strategies (Task 3.2)
• Testing of risk mitigation strategies
• Assessment of domain-specific production control strategies

Task 2.4 Use-Case #2: Implementation – small lot production (Lead: MGS)
Use case #2 implements the small lot production of aircraft interior equipment use-case in stimulus models based on discrete event simulation model. The use case addresses the horizontal integration of planning and control concepts. The models will be used for the trails and the benchmark of ARUM approach in task 7.3.

Content of work:
• Set up a production model for the use-case, validate and verify the corresponding simulation models
• Definition of interfaces to legacy system
• Integration of required legacy systems by interfaces or via real data samples
• Simulation of use-case in real-time environment with selected risks
• Application of business strategies (Task 3.2)
• Testing of risk mitigation strategies
• Assessment of domain-specific production control strategies

Task 2.5 Use-Case #3: Implementation – small lot production (Lead: EADS)
Use case #3 shall support the prove of applicability of the ARUM architecture for non-aerospace sectors, e.g. for the small lot production of RoRo-Vessels or for an automotive application. Based on the definition of scope and complexity in task 2.1 the use-case will be implemented as a case study for the assessment in task 7.2 or more complex will implement stimulus models based on discrete event simulation model for benchmarking in task 7.3.

Content of work (provisorily task 2.1 decision on scope, etc.):
• Set up a production model for the use-case, validate and verify the corresponding simulation models
• Application of business strategies (Task 3.2)
• Simulation based testing of risk mitigation strategies
• Assessment of domain-specific production control strategies

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	19.00
2	AIB	9.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
3	CER	4.00
4	MGS	14.00
5	TIE	7.00
6	SMRT	2.00
7	ALM	4.00
8	CUAS	14.00
9	P3	16.00
12	ICCS	2.00
13	CTU	4.00
14	UNIHA	22.00
	Total	117.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D2.1.1	Use-Case Definition (use cases #1 & #2)	1	14.00	R	RE	7
D2.1.2	Use-Case Definition (use case #3)	1	8.00	R	RE	13
D2.2.1	Use-Case Detailing and KPI setting	9	27.00	R	RE	13
D2.3.1	Use-Cases #1: Implementation (new product ramp-up)	2	30.00	O	RE	28
D2.4.1	Use-Cases #2: Implementation (Small lot production #1)	4	23.00	O	RE	28
D2.5.1	Use-Cases #3: Implementation (Small lot production #2)	1	15.00	O	RE	28
		Total	117.00			

Description of deliverables

D2.1.1) Use-Case Definition (use cases #1 & #2): Description of the aerospace related use cases (#1 & #2) with respect to scope, addressed industrial challenges, included legacy systems etc. [month 7]

D2.1.2) Use-Case Definition (use case #3): Definition and description the non-aerospace related use case (#3), especially its complexity and implementation concept (case study, simulation study, etc.) [month 13]

D2.2.1) Use-Case Detailing and KPI setting: Detailed description of all use cases including the KPI setting. Will be input for WP 3, 4 and 5 for development of strategies and software modules. [month 13]

D2.3.1) Use-Cases #1: Implementation (new product ramp-up): Simulation model (stimulus) and industrial data needed for ARUM benchmarking in WP7 for Airbus application (vertical integration) [month 28]

D2.4.1) Use-Cases #2: Implementation (Small lot production #1): Simulation model (stimulus) and industrial data needed for ARUM benchmarking in WP7 for MGS application (horizontal integration) [month 28]

D2.5.1) Use-Cases #3: Implementation (Small lot production #2): based on D2.1-2 definition the case study setup or more complex implementations for simulation studies, etc. [month 28]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS2	End-user requirements defined	1	7	Availability of requirements and use case definition
MS8	Use case definition finished, use case #3 scope and size specified	9	13	Use cases defined and decision on use case #3 (domain, case study, simulation, etc.) is made
MS16	ARUM trails objectives and focus	1	23	ARUM trails focus and objectives defined
MS18	Participants for target workshops selected	1	18	Participants for target WS in WP7 (ARUM demonstrations) selected
MS19	Number of show cases and target audience defined	1	28	Out of the use case definition the number of show cases in WP8 and target audience is defined

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP3	Type of activity [54]	RTD
Work package title	Ramp-up & Production Strategies		
Start month	1		
End month	28		
Lead beneficiary number [55]	9		

Objectives

The WP 3 objective is to develop new beneficial business strategies to optimize ramp-up and production management (in particular small lot production management).
In focus are strategies for risk reduction and mitigation in product system planning phase of production ramp-up and small lot production (flexible versus robust production strategy and associated resource planning, shop floor layout, etc.) and risk management strategies in real-time management of production ramp-up and small lot production (decision making logics)
The WP will transfer the developed risk mitigation and management strategies into formal representation (ontologies for knowledge representation, decision rules) for usage in knowledge-processing tools supporting automated control and optimization in WP5

Description of work and role of partners

Task 3.1 Best Practice Ramp-up & Small Lot Production Strategies (Lead: P3)
To identify ramp-up & small lot production best practise business strategies in the industrial environment for future ramp-up & production scenarios.

Content of work:
• To identify best practise business strategies in ramp-up production and small lot production scenarios:
o Analysis of principle business strategies as flexible / agile / robust manufacturing
o Analysis the de-risking potential of business strategies
o Analysis of production system setups implementing different business strategies (de-risking potential, risk mitigation costs)
• To conclude the benefits and disadvantage of different business strategies for risk reduction and management and their implementation requirements and impacts on different management levels (strategic, tactical and operative)

Task 3.2 Beneficial ARUM Business Strategies (Lead: P3)
To selects beneficial business strategies according to use case descriptions and to transfer the strategies into formal representation for later on use in WP5 knowledge processing tools.
As the selected beneficial business strategies are implemented within WP5 and WP4, a close interaction within the WPs will be mandatory. This will mainly result out of the business strategies' adaptation issues within the system architecture/interfaces and automation control. In order to secure a robust adaptation, WP3 will balance and align the demands between the industrial requirements (task 1.3), the beneficial business strategies (task 3.2), system architecture/interfaces and automation control as well as tools and updating of knowledge models (WP4/WP5) in regular improvement loops. Additional critical issues will be reviewed in Ad-hoc meetings, in order to launch quick solution finding.

Content of work:
• To select the business strategies / de-risking strategies most applicable for ARUM use cases:
o Setup the selection criteria for strategy selection
o Assess the strategies in terms of applicability for the use cases and in terms of contribution for de-risking, operational and economic benefit
o Ranking and selection
• Detailed description the strategies for ARUM

• Support of iteration loops for adaptation

Task 3.3 Knowledge Modeling Strategy (Lead: CUAS)
Multi-agent Systems as envisioned for ARUM process knowledge as captured in domain- or user-ontologies and compiled for software-machines (agents). Capturing is to be organi¬zed in iterative work with users entering into "version-1 ontology". This ontology will serve as starting point for improving learning curves in time-to-volume manufacturing strategies as well as for the development of ontology finally implemented in the ARUM Factory Network (task 5.2) supporting
• the variety of use-cases (e.g., including details of concrete resources, workers etc.)
• new knowledge about risks or eventuated problems and alternative plans.

The latter refers to the fact that particularly ramp-up phases are marked by unexpected events with a high impact on time-to-volume and with this on the returns on investment into products and production systems. Response to such events may among others include structural adaptation of the knowledge-base active in the Factory Network and Scenario Designer ("on the fly" and on their own resources, i.e. without support of software developers) in order to analyze and evaluate impact as well as support mitigation – supported by a highly flexible enabling users as far as feasible
In ARUM knowledge gathering and maturing starts from the very beginning in parallel and accordan¬ce to Strategy Definitions (tasks 3.1, 3.2) and in the course of Bench¬marking, Production System Analysis, and Scenario Requirements Analysis (WP 1), Use-Case elabora-tion (WP2).

Content of work:
• develop the ontology collaboratively with users in the scope of selected use-cases
• bring about an agreement on standards of ontology design, the choosing of an ontology management tool (OMT) and
• define requirements for plug-ins / add-ons for OMT for simulation, planning and real-time control in the need to extend it to meet standards,
• elaborate requirements to be met by the ontology implemented in the Factory Network and Scenario Designer and of test scenarios with regard to the adaptiveness to new insights (final decision in task 5.2).
• To specify methods of agent-based reasoning on ontologies of manufacturing which support extension / adjustment of ontologies "on the fly" during execution stage
• To define a set of test- and demo-scenarios for customizing ontology-driven models of workshops and expanding ontologies "on the fly".
• lay the ground for developing a MAS-augmented learning curve for small-lot manufacturing operations and ramp-up conditions.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	8.00
2	AIB	2.00
3	CER	4.00
4	MGS	4.00
6	SMRT	2.00
8	CUAS	6.00
9	P3	25.00
10	UNIMAN	8.00
11	IPB	2.00
12	ICCS	3.00
13	CTU	2.00
14	UNIHA	10.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
	Total	76.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D3.1.1	Best Practice Ramp-up & Small Lot Production Strategies	9	26.00	R	PU	9
D3.2.1	Beneficial ARUM Business Strategies (1st release)	9	9.00	R	RE	19
D3.2.2	Beneficial ARUM Business Strategies (2nd release)	9	10.00	R	RE	25
D3.2.3	Beneficial ARUM Business Strategies (final release)	9	10.00	R	RE	28
D3.3.1	SoA and selection of OMT	8	5.00	R	RE	7
D3.3.2	ARUM Ontology version-1	8	8.00	O	RE	13
D3.3.3	Learning-curve Strategy	8	8.00	R	RE	19
		Total	76.00			

Description of deliverables

D3.1.1) Best Practice Ramp-up & Small Lot Production Strategies: Ramp-up & small lot production best practice business strategies are identified [month 9]

D3.2.1) Beneficial ARUM Business Strategies (1st release): Beneficial business strategies according to use case descriptions have been selected and requirements aligned with WP4 & WP5 (iteration loops). [month 19]

D3.2.2) Beneficial ARUM Business Strategies (2nd release): Beneficial business strategies according to use case descriptions have been selected and requirements aligned with WP4 & WP5 (iteration loops). [month 25]

D3.2.3) Beneficial ARUM Business Strategies (final release): Beneficial business strategies according to use case descriptions have been selected and requirements aligned with WP4 & WP5 (iteration loops). [month 28]

D3.3.1) SoA and selection of OMT: Analysis of state-of-the-art in OMT and selection of the OMT and potential extensions used in ARUM and being in accordance with the standardization strategy for ontology editing, compiling and translation into factory network design with the objective to enable users to a larger degree of adapting the MAS to change and learning on their own resources. [month 7]

D3.3.2) ARUM Ontology version-1: Version-1 of the ARUM ontology about product, factory resources and processes, KPI etc. in accordance to ARUM business strategy as well as to decisions made in D3.3-1. Ontology will be provided also in digital format. [month 13]

D3.3.3) Learning-curve Strategy: Elaboration of a strategy establishing learning curves for small series manufacturing with particular respect to ramp-up conditions [month 19]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS7	Specification phase completed	3	15	Availability of all specifications
MS9	1st Software release (tools, architecture); business strategies definition 1st draft	3	18	Methods, Tools, Architecture 1st release available
MS10	2nd Software release (tools, architecture); business strategies definition 2nd draft	3	25	Methods, Tools, Architecture 2nd release available
MS11	Software final releases, business strategies finalized and reviewed	3	28	Methods, Tools, Architecture final release available and reviewed

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP4	Type of activity [54]	RTD
Work package title	System Architecture and Interfaces		
Start month	6		
End month	28		
Lead beneficiary number [55]	10		

Objectives

This activity will result in an enterprise-wide system integrating advances in scalable interoperability provided by service-oriented architectures with intelligent information processing and manufacturing control provided by holonic multi-agent systems. It will establish the conceptual and technical foundations of an integrated platform ensuring purposeful and unobstructed flow of information between decision makers, intelligent planning, scheduling, optimization and control tools and the legacy systems providing real-time information about the status of processes. To reflect these characteristics, we call the main system “intelligent enterprise service-based platform (i-ESB Platform)”.

Description of work and role of partners

Task 4.1 Functional and Performance Requirements for ARUM Solutions (Lead: CER)
This task aims to establish the functional and performance requirements towards the ARUM solutions to be developed within WP4 and WP5. It will take the end-user requirements established in WP1, and convert them to specific requirements guiding software development. The
Content of work:
• Analyze different groups of software users, profile their skill levels and establish the type of interface which should be developed.
• Determine performance requirements of ICT, e.g. response time, data volume, etc.
• iESB concept & specification
• Specify legacy system interfaces & interaction modes
• Establish desired functionality to create priorised functional requirements.
• Establish data dictionary regarding key data to be processed by the ARUM solution.

Task 4.2 System Architecture and Platform Specifications (Lead: UNIMAN)
To creates the specification of the overall architecture and of the management platform to enable the construction of large-scale multi-level enterprise systems for manufacturing. In our vision such systems are organized as p2p networks of holonic agents sitting on top of Service-Oriented ESB facilitating real-time flow of information and flexible integration with legacy systems. Our platform allows agents to provide services, communicate directly using p2p architecture and compete or cooperate in process of manufacturing, resulting in event-driven time critical and energy efficient decisions in real time.
Content of work:
• Advance the concept of “intelligent services-based factory”, combining Semantic Web and multi-agent technologies.
• Identify core technological constraints to be observed in the architecture design, including interaction models with agents and legacy systems.
• Design the iESB architecture allowing the incorporation of holonic-agent-based modules developed in WP4 into enterprise applications with legacy systems. The architecture will include core modules, interfaces, components and interaction channels.
• Design the top-layer of peer-to-peer (p2p) architecture allowing the cooperation and competition of holonic agent-based systems including planners and other decision-support tools.
• Design event-based mechanisms for triggering communications, horizontal and vertical coordination mechanisms and protocols of communication and programming interfaces for systems interaction in real time.

• Specify core services, mechanisms and modules, including mechanisms for resource and component allocation, component migration, data storage and persistence, directory and event management, among others.
• Design i-ESB Platform Manager and user-friendly dash-boards for monitoring manufacturing process and business KPIs (“business radar”)
• Specify extension mechanisms allowing the deployment of additional components at system runtime, allowing automatic migration of components and overall autonomic capabilities. These mechanisms will prepare the platform for eventual ramp-ups where ARUM is expected to support.

Task 4.3 Legacy System Integration (Lead: TIE)
To ensure generic legacy system modules can be integrated within the platform into specific applications developed using ARUM technology.
Content of work:
• Specify legacy system interfaces and interaction models.
• Develop a legacy system integration module for the platform, including a testing adaptor.

Ensure the provision of user-driven data for implementation of use cases by developing modules for collecting data from legacy systems. To facilitate this action the Integration approach will be focused on augmenting the TIE SmartBridge product which in turn will ensure neutral interconnectivity. This will assist and allow maximal exploitation. To ensure future use by partners TIE will, as standard, allow use of such product during the project and for user partners for a further two years without charge (based on project deliverables)

Task 4.4 Platform Development (Lead: CER)
To develop the deployment and management platform to enable the construction enterprise systems using the architecture developed in WP4 and the tools developed in WP5.
Content of work:
• Implement platform middleware and services.
• Implement iESB Core Platform Modules including a user-friendly dashboard and a platform manager which visualize running components, sites, resource utilization, data storage, etc.
• Implement p2p integration layer as an upper layer of i-ESB Platform. Deliver the first prototype of the holonic p2p layer and the enterprise service bus for horizontal interaction and cooperation of real-time schedulers.
• Deliver the advance holonic p2p platform on the basis of collected requirements, users feedback, experience and lessons learned in the use-case #1
• Integrate the legacy system integration module with platform
• Integrate and test iESB platform

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	4.00
3	CER	27.00
4	MGS	5.00
5	TIE	38.00
6	SMRT	51.00
7	ALM	15.00
10	UNIMAN	26.00
11	IPB	20.00
12	ICCS	27.00
13	CTU	15.00
14	UNIHA	8.00
	Total	236.00

WT3:
Work package description

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D4.1.1	SoA and System Architecture and Platform Specifications 1st draft	10	20.00	R	RE	13
D4.1.2	System Architecture and Platform Specifications	10	19.00	R	RE	15
D4.2.1	First prototype of iESB components and P2P agents layer	3	68.00	P	RE	19
D4.3.1	Legacy System Integration Specifications and Components (1st release)	5	12.00	P	RE	19
D4.3.2	Legacy System Integration Specifications and Components (2nd release)	5	22.00	P	RE	25
D4.3.3	Legacy System Integration Specifications and Components (final release)	5	12.00	P	RE	28
D4.4.1	iESB platform and guides (user and programmer)	3	83.00	P	RE	28
		Total	236.00			

Description of deliverables

D4.1.1) SoA and System Architecture and Platform Specifications 1st draft: State of the art analysis the existing / partner provided architecture and platform solutions as baseline for further specification the ARUM System Architecture and Platform. First draft System Architecture and Platform Specification. [month 13]

D4.1.2) System Architecture and Platform Specifications: Finalization the D4.1-1 draft to System Architecture and Platform Specifications captures the results of T4.1 and T4.2, providing both a list of prioritized functional and non-functional requirements and the system architecture which is constructed by T4.2 to fulfil those requirements. This deliverable will be due in Month 15, benefitting from some early feedback from the development of the first prototype due in Month 18. [month 15]

D4.2.1) First prototype of iESB components and P2P agents layer: First prototype of iESB components and P2P agents layer will serve as early validation of both the architectural decisions and of the functional and non-functional requirements, and will be shown to other work packages to allow coordination of work and approaches. [month 19]

D4.3.1) Legacy System Integration Specifications and Components (1st release): Legacy System Integration Specifications and Components will take the format of a report (specifications) and prototype (components). The deliverable will be delivered in multiple releases (iterative development, releases at month 19, 25 and 28) [month 19]

D4.3.2) Legacy System Integration Specifications and Components (2nd release): Legacy System Integration Specifications and Components will take the format of a report (specifications) and prototype (components). The deliverable will be delivered in multiple releases (iterative development, releases at month 19, 25 and 28) [month 25]

D4.3.3) Legacy System Integration Specifications and Components (final release): Legacy System Integration Specifications and Components will take the format of a report (specifications) and prototype (components). The deliverable will be delivered in multiple releases (iterative development, releases at month 19, 25 and 28) [month 28]

D4.4.1) iESB platform and guides (user and programmer): iESB platform and guides (user and programmer) will be a software prototype complemented by a report comprising the user guide and the programmer guide. [month 28]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS7	Specification phase completed	3	15	Availability of all specifications
MS9	1st Software release (tools, architecture); business strategies definition 1st draft	3	18	Methods, Tools, Architecture 1st release available
MS10	2nd Software release (tools, architecture); business strategies definition 2nd draft	3	25	Methods, Tools, Architecture 2nd release available
MS11	Software final releases, business strategies finalized and reviewed	3	28	Methods, Tools, Architecture final release available and reviewed

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP5	Type of activity [54]	RTD
Work package title	Methods & Tools for Adaptive Planning, Scheduling, and Optimization		
Start month	6		
End month	28		
Lead beneficiary number [55]	3		

Objectives

WP5 develops a comprehensive set of methods and tools for advanced capacity planning, resource scheduling and production optimization at strategic, tactical and real-time levels. The development is driven by functional and performance requirements defined in WP 4.1. The result of this WP is a set of set of independent software tools implementing methods for advanced planning, scheduling and optimizations. The tools are integrated by means of
i-ESB platform (WP4) into a holistic software environment supporting the implementation of manufacturing use cases (WP2) and relevant business strategies (WP3).

Description of work and role of partners

Task 5.1 Specification of Methods and Tools for Adaptive Planning, Scheduling, and Optimization (Lead: CER)
The task 5.1 objective is to refine functional and performance requirements defined in task 4.1 with focus on methods of rump-up risk management and related tools for strategic, tactical, and operational resource planning, scheduling, and dynamic optimization. The requirement specification should embrace a demand for adaptability to unrecognized or underrated risks (so called “black swans”) such as supply shortages, product design failures, late change requests from customers, etc.

Task 5.1 will benefit from experiences and user feedback gained during the pilot deployment of scheduler in a small workshop, which is planned in the early phase of the project (task 1.3). The results of WP1.3 will help to specify how the existing scheduling tools have to be adjusted and enhanced in order to accommodate specific features of ramp-up use cases (WP2).

Task 5.1 will also leverage the experiences gained in task 3.3 during the design of initial manufacturing ramp-up ontologies in selected Ontology Management Toolset (OMT). Task 5.1 will make a final decision on suitability and possible adjustments of OMT’s libraries and APIs needed for implementation of the ontology manipulation engine in respective tools of task 5.2.

Content of work:
• To derive functional and performance specifications of methods and tools for:
(a) factory network and scenario designer,
(b) strategic planning and optimization, and
(c) tactical and operational planning, scheduling, and optimization;
• To review existing methods and tools for planning, scheduling, optimization, select the most suitable ones, and define guidelines for adjustments and enhancements needed in order to satisfy the specifics of ramp-up uses cases;

Task 5.2 Factory Network and Scenario Designer (Lead: CUAS)
Objective of task 5.2 is development of the Factory Network Designer (FND) for specification of the workshop model (production lines, equipment, workers, tools, operations, etc.), and the Scenario Designer (SD) for modeling of alternative ramp-up scenarios and suitable risk- and contingency-management strategies.
The models created in both tools are internally represented by ontologies and thus a kind of ontology engine is required to provide the underlying manipulation with ontologies (creation of classes/instances, consistency checking, etc.). The engine will leverage APIs and libraries provided by Ontology Management Toolsets (selected in WP3) in form of plug-ins or services. The UI of FND and SD will be decoupled from ontology engine

to allow the user, who is the domain expert, to enter his knowledge in an easy way, without being concerned with the underlying ontology models. It will also allow for creation of multiple independent Uis targeted to specific use (thick clients to be used by plant managers, thin clients to be used by plant operators and workers equipped with touch screen terminals, etc.).

The final ARUM use-case specific ontologies created in task 3.3 will be utilized in FND and SD in order to execute trials, assessment and validation of ARUM in WP7.

The main feature of FND and SD is the support for modifications and extensions of the models on the fly. The user will be enabled to enter the new knowledge regarding the problems, unexpected events, and contingencies they encounter during their everyday work. The user can easily introduce new sub-classes of problems (for instance delay of materials or lack of instruments) and integrate them into the existing network. Such an expansion of knowledge model is propagated via i-ESB (WP4) to planners (task 5.3) and schedulers (task 5.4) where it triggers adaptation of existing schedules in order to mitigate the risks and their economic impacts. This principle is called “What You Know Is What You Get” – the insertion of the new knowledge (what you know) triggers imminent change and adaptation of the scheduling system behavior (what you get).
The fusion of knowledge to agent-based planners and schedulers is supported by consistent application of SoA principles. Each relation between ontology objects is interpreted by agents as matching of the service demand and supply. Such principle is expected to significantly reduce complexity of design and redesign of ontology and related software systems.

The Factory Network Designer will be also used to implement KPI estimation and evaluation knowledge models with regard to economic (costs/benefits, opportunity costs of alternative action) and environmental (estimated GHG-emissions) efficiency (task 2.2).

Content of work:
• Development of Factory Network Designer and Scenario Designer according to specifications and guidelines defined in task 5.1;
• Design of KPI estimation and evaluation knowledge models.

Remark: Some consortium members have a track record in showcasing the benefit of simulation SW and use of MAS for industrial automation. Since the combination of both approaches represents a critical path for the project success task 5.2 will start early at month 7 in order to share and start integrating the expertise available in the consortium.

Task 5.3 Strategic Planning and Optimization Methods and Tools (Lead: CER)
Objective of task 5.3 is to develop the software tool providing high-level decision support concerning strategic planning. In particular, the tool provides means for efficient handling of contingencies (cancelled orders, machine failures, supply shortages, late change requests, etc.) in terms of elaboration and evaluation of alternative plans. The tool is developed as a multi-agent system, with knowledge-based agents designed according to SoA principles.

The key features are:
• Support for planning at strategic level; continuous re-planning according to the current flow of orders;
• On-line interaction with Factory Network and Scenario Designers over the i-ESB for gathering knowledge models and run-time updates reflecting changed conditions or unexpected events;
• On-line interaction with legacy systems via i-ESB in order to get real-time data from shop floor as well as to interact with the MES/ERP data management systems;
• Support for simulation and evaluation of alternative scenarios (plans) to be applied to mitigate risks and impact on economic and environmental efficiency;

Content of work:
• To design method for strategic capacity planning based on virtual market principles with adaptive matching of demands and supplies;
• To implement Strategic Planning and Optimization tool;
• To develop KPI calculation and estimation modules for simulation-based evaluation of economic efficiency of strategic planning

Task 5.4 Tactical and Operational Planning, Scheduling, and Optimization Methods and Tools (Lead: SMRT)
Objective of task 5.4 is to develop the software tool providing decision support concerning tactical and operational planning, scheduling and real-time optimization methods. The tool refines general plans coming from

the strategic planning level and elaborates detailed workshop schedules. The main feature of the tool is support for efficient handling of either planned or unplanned events in real time time such as changing volume of orders, high priority orders, holiday times, worker's illnesses, large repairs, etc. The tool is developed as a multi-agent system, with knowledge-based agents designed according to SoA principles. The swarm of agents apply virtual market mechanisms for finding optimal matching of demands and supplies. Multiple workshop scheduling tools can cooperate in a holonic p2p network in order to achieve coordination of interdependent schedules over the factory.

The key features are:
• Online interaction with Factory Network and Scenario Designers, and Strategic Planning and Optimization Tool;
• On-line interaction with legacy systems via i-ESB in order to get real-time data from shop floor as well as to interact with the MES/ERP data management systems
• Support for tactical and operational planning and scheduling; continuous re-allocation and re-scheduling of resources, resource utilization optimization, monitoring and control of execution of plans in real time;
• Support for simulation and evaluation of alternative scenarios in order to efficiently adapt to planned/unplanned events in real time;
• Support for cooperation with other schedulers for coordination of interdependent schedules.

Content of work:
• To design method for tactical and operational planning, adaptive scheduling, optimization resource allocation optimization;
• To implement Tactical and Operational Planning, Scheduling and Optimization tool;
• To develop KPI calculation and estimation modules for real-time evaluation of economic efficiency of operational scheduling

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	5.00
3	CER	80.00
4	MGS	2.00
6	SMRT	58.00
7	ALM	25.00
8	CUAS	20.00
10	UNIMAN	14.00
11	IPB	26.00
12	ICCS	6.00
13	CTU	34.00
14	UNIHA	12.00
	Total	282.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D5.1.1	Methods and tools specifications	3	32.00	R	RE	13

WT3:
Work package description

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D5.1.2	Concept of knowledge management tools integration into engineering process of WP5	3	10.00	R	RE	7
D5.2.1	Factory Network and Scenario Designer (1st release)	8	22.00	P	RE	19
D5.2.2	Factory Network and Scenario Designer (2nd release)	8	22.00	P	RE	25
D5.2.3	Factory Network and Scenario Designer (final release)	8	23.00	P	RE	28
D5.3.1	Strategic Planning and Optimization Tool (1st release)	3	23.00	P	RE	19
D5.3.2	Strategic Planning and Optimization Tool (2nd release)	3	23.00	P	RE	25
D5.3.3	Strategic Planning and Optimization Tool (final release)	3	22.00	P	RE	28
D5.4.1	Tactical and Operational Planning, Scheduling and Optimization Tool (1st release)	6	35.00	P	RE	19
D5.4.2	Tactical and Operational Planning, Scheduling and Optimization Tool (2nd release)	6	35.00	P	RE	25
D5.4.3	Tactical and Operational Planning, Scheduling and Optimization Tool (final release)	6	35.00	P	RE	28
		Total	282.00			

Description of deliverables

D5.1.1) Methods and tools specifications: consists of functional and performance specifications and high-level software design specifications [month 13]

D5.1.2) Concept of knowledge management tools integration into engineering process of WP5: Although the tool integration and customization is a central challenge across different work packages, the terminology of a tool as such needs further consideration, e.g what is the maturity and readiness for use, what are the means to bring a tool to industrial up-take and commercialization, what documentation, user interfaces, strategy for relapses and openness to Third Party is needed, what is the IPR model if a ARUM tool integrates elements of an existing commercial tool into a framework. The report describes the starting point of knowledge management tools and their integration in the engineering process in WP5. [month 7]

D5.2.1) Factory Network and Scenario Designer (1st release): 1st release of Factory Network Designer and Scenario Designer software tools [month 19]

D5.2.2) Factory Network and Scenario Designer (2nd release): 2nd release of Factory Network Designer and Scenario Designer software tools, including user's guide [month 25]

D5.2.3) Factory Network and Scenario Designer (final release): final release of Factory Network Designer and Scenario Designer software tools, based on first integration results of WP6 [month 28]

D5.3.1) Strategic Planning and Optimization Tool (1st release): 1st release of Strategic Planning and Optimization software tool [month 19]

D5.3.2) Strategic Planning and Optimization Tool (2nd release): 2nd release of Strategic Planning and Optimization software tool, including user's guide [month 25]

D5.3.3) Strategic Planning and Optimization Tool (final release): final release of Strategic Planning and Optimization software tool; based on first integration results of WP6 [month 28]

D5.4.1) Tactical and Operational Planning, Scheduling and Optimization Tool (1st release): 1st release of Tactical and Operational Planning, Scheduling and Optimization software tool [month 19]

D5.4.2) Tactical and Operational Planning, Scheduling and Optimization Tool (2nd release): 2nd release of Tactical and Operational Planning, Scheduling and Optimization software tool, including user's guide [month 25]

D5.4.3) Tactical and Operational Planning, Scheduling and Optimization Tool (final release): final release of Tactical and Operational Planning, Scheduling and Optimization software tool; based on first integration results of WP6 [month 28]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS7	Specification phase completed	3	15	Availability of all specifications
MS9	1st Software release (tools, architecture); business strategies definition 1st draft	3	18	Methods, Tools, Architecture 1st release available
MS10	2nd Software release (tools, architecture); business strategies definition 2nd draft	3	25	Methods, Tools, Architecture 2nd release available
MS11	Software final releases, business strategies finalized and reviewed	3	28	Methods, Tools, Architecture final release available and reviewed

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP6	Type of activity [54]	RTD
Work package title	Integration		
Start month	13		
End month	37		
Lead beneficiary number [55]	5		

Objectives

The WP6 objective is to integrate the ARUM Platform with ontology and virtual market mechanism and connect the ARUM Platform to the existing legacy system. The Modelling of the use- cases give an overview about technologies solutions for adaptive manufacturing ramp-up managements.
The ARUM test bed will be compiled by computation infrastructure (server, communication means) and connections to industrial environment (legacy systems of industrial partners) and simulation systems used by use cases for scenario implementation. The ARUM test bed will be installed at EADS / AIB premises and for use case #2 at MGS premises.

Description of work and role of partners

Task 6.1 ARUM Integration Testbed (Lead: TIE)
The ARUM integration test bed will provide the technical infrastructure for running the ARUM integrated solution for trails and benchmarking and demonstration.

Content of work:
• To specify the ARUM test bed based on use case definitions WP2 and requirements from technical WP 4, 5 and benchmarking task 7.3
• To integrate the technical elements (server, communication infrastructure, etc.) and basic software (simulation SW, basic operating software, etc.) of the ARUM test bed
• Validation of functionality

Task 6.2 Overall System Integration (Lead: TIE)
To integrate the ARUM software modules coming from WP4 and WP5 and additional elements (e.g. ontologies from WP3) using the ARUM integration test bed.

Content of work:
• To integrate all M&T into platform
• Integration and verification of interfaces to legacy systems
• Integration and verification of use case simulation models for benchmarking

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	6.00
3	CER	15.00
4	MGS	2.00
5	TIE	12.00
6	SMRT	10.00
7	ALM	6.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
8	CUAS	3.00
10	UNIMAN	6.00
11	IPB	4.00
12	ICCS	6.00
13	CTU	5.00
14	UNIHA	7.00
	Total	82.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D6.1.1	ARUM Integration Testbed ready for Integration	5	33.00	O	RE	23
D6.2.1	Overall System Integration first release	5	24.00	P	RE	28
D6.2.2	Overall System Integration & Verification	5	25.00	P	RE	31
		Total	82.00			

Description of deliverables

D6.1.1) ARUM Integration Testbed ready for Integration: The ARUM physical testbed is available for integration the software modules from WP4, WP5. Technical infrastructure is installed at Airbus / EADS premises for use case #1,#3 and at MGS premises for use case #2 related integration. [month 23]

D6.2.1) Overall System Integration first release: The overall ARUM software solution (modules from WP4, WP5 and ontologies from WP3) first integration release is available. [month 28]

D6.2.2) Overall System Integration & Verification: The overall ARUM software solution (modules from WP4, WP5 and ontologies from WP3) is integrated at ARUM testbed and interfaces to legacy systems (industrial environment) and to simulation models (benchmarking in task 7.3) are validated. [month 31]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS12	ARUM solution integrated	5	31	ARUM solution available
MS14	ARUM solution first integration release	5	28	ARUM solution first draft integration available

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP7	Type of activity [54]	DEM
Work package title	Trials, Assessment & Validation		
Start month	23		
End month	37		
Lead beneficiary number [55]	1		

Objectives

In WP7 the ARUM technical results, (integrated ICT solutions), will be validated through the use-cases defined in WP2 and against the end-user requirements derived in WP1 and detailed into functional requirements in WP3, WP4 and WP5. Based on trails for technical performance assessments the ARUM solution will be benchmarked with today's industrial ICT solutions of industrial partners.
Secondly the operational, economic and ecological benefits will be assessed and the achievement of global ARUM targets by developed solution will be validated.

Description of work and role of partners

Task 7.1 ARUM Trials (Lead: EADS)
To run technical evaluation trails of ARUM integrated solution to assess the technical performance as specified. To validate the ARUM solution against the end-user requirements (task 1.3) and functional requirements (task 4.1, task 5.1). The trails will be performed using the ARUM test bed (WP6) and the use-cases defined in WP2.

Content of work:
• To plan the ARUM trails campaign based on end-user requirements defined in WP1 and use cases defined in WP2 and on specification and test planning from WP 4 and WP5
• To integrate the assessment needs from benchmarking task 7.3 (KPI, test cases)
• To select group of 2-3 target workshops in use-case A, B or C factory and install holonic p2p platform for demonstrating benefits of horizontal collaboration of 2-3 real time schedulers on the early stage of the project (17 month).
• To select 2-3 target workshops in use-case B and C factory and reinstall advanced holonic p2p platform for demonstrating benefits of horizontal collaboration of 2-3 real time schedulers
• To perform the planned test cases by running the us cases and collect the KPI measurements
• To evaluate the KPIs

Task 7.2 Assessment of Operational, Ecological, Economical Effects (Lead: P3)
To assess operational, ecological and economic effects which result from using the ARUM approach. The assessment will base on measured performance KPI in task 7.1 and models for operational, economic and ecological assessment of production systems. The task will validate the overall ARUM quantitative targets especially for planning and ramp-up costs.

Content of work:
• Development an assessment concept for ARUM solution
• Identification of KPI assessing operational, ecological effects, e.g. costs, resources and energy consumption
• Identification of applicable models, tools and assessment schemes available and selection and adaptation to assessment concept
• Execution the assessments based on task 7.1 results
• Benefit analysis and conclusion the ARUM assessment report.

Task 7.3 Benchmark of ARUM approach (Lead: UNIHA)
To execute the benchmark of ARUM against today's ICT solutions of use case industrial partners and to validate the quantitative targets for production delay reduction and production volume increase formulated by ARUM.

For that the industrial environment will be connected to ARUM test bed and completed by use case simulation models (event stimulus models).

Content of work:
• To identify the relevant benchmarking partners out of the defined industrial use cases
• To define the benchmarking plan and KPI for ARUM solution benchmark against today's industrial solutions
• To execute the benchmarking relevant trails and scenarios at ARUM test bed (in close collaboration with WP 7, Task 7.1) and to measure the relevant benchmarking KPI
• To analyze the benchmarking results and to compile the benchmarking report

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	16.00
2	AIB	8.00
3	CER	7.00
4	MGS	15.00
5	TIE	6.00
6	SMRT	9.00
7	ALM	9.00
8	CUAS	8.00
9	P3	9.00
10	UNIMAN	1.00
11	IPB	4.00
12	ICCS	5.00
13	CTU	3.00
14	UNIHA	6.00
	Total	106.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D7.1.1	ARUM trials planning	1	6.00	R	RE	25
D7.1.2	ARUM Trials	1	28.00	R	RE	34
D7.2.1	Assessment of Operational, Ecological, Economical Effects	9	30.00	R	RE	37
D7.3.1	Benchmark of ARUM approach	14	42.00	R	RE	37
		Total	106.00			

Description of deliverables

WT3:
Work package description

D7.1.1) ARUM trials planning: ARUM trails plan including definition of target workshops, focus and participants [month 25]

D7.1.2) ARUM Trials: Report including the test reports from ARUM software trails based on use cases [month 34]

D7.2.1) Assessment of Operational, Ecological, Economical Effects: Assessment report on ARUM benefits and validation for ARUM overall target achievements [month 37]

D7.3.1) Benchmark of ARUM approach: Benchmark results of ARUM solutions against todays industrial solutions for selected use cases [month 37]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS16	ARUM trails objectives and focus	1	23	ARUM trails focus and objectives defined
MS18	Participants for target workshops selected	1	18	Participants for target WS in WP7 (ARUM demonstrations) selected

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP8	Type of activity [54]	OTHER
Work package title	Show cases		
Start month	31		
End month	37		
Lead beneficiary number [55]	4		

Objectives

The objective of the WP8 “Show cases” is to disseminate and exploit ARUM research findings across scientific and industrial communities. Within the work package a set of show cases for the ARUM solutions will be performed in front of end-users.
Based on show case workshops with end-users (industrial partners, EAB members) a validation of ARUM solution shall be carried out.

Description of work and role of partners

Task 8.1 Show cases (MGS)
The objective of this work package is to present the achieved results of the project to potential end-users and to the project stakeholders in a number of show cases based on use cases from WP3.

Content of work:
• Preparation the show cases
Identification of the relevant use cases and scenarios best representing the project achievements under various aspects and which are practical for show case purposes.
Based on the selected uses cases and scenarios a presentation concept has to be compiled and the show cases have to be defined in detail. The show cases shall include ramp-up as well as small lot production examples.

• Show cases planning
The planning considers the discrete and practical planning of the show cases and the involvement of the stakeholders.

• Show case Preparation and Performance Measurement
The practical preparation of the facilities for the integration and implementation of the technical items needed for performance measurements and the first performance measurements it selves.

• Show Case Workshops
Workshops together with potential end-users and the project stakeholders as planned for the ramp-up and small lot production related show cases

• Collect feedback and evaluation of the result
• A detailed reporting of the results of workshops, results will become inputs for the following Exploitation & Dissemination WP 9.

Task 8.2 End-User Validation (Lead: EADS)
To carry out the end-user validation with ARUM industrial partners and EAB members

Content of work:
• Comparison of end-user requirements of Task 1.3 with results from performance analysis (Task 7.2 and 7.3)
• Validation of workshop results and end-user feedback on shown ARUM approaches in workshops with practitioners from industrial partners and EAB
• Identification of improvements and required adaption which need to be implemented in the ARUM solution
• To propose future steps in further development / research based on ARUM project results from end-user / industry point of view

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	3.00
2	AIB	4.00
3	CER	4.00
4	MGS	8.00
5	TIE	1.00
6	SMRT	5.00
7	ALM	2.00
8	CUAS	1.00
9	P3	1.00
10	UNIMAN	5.00
11	IPB	1.00
12	ICCS	1.00
13	CTU	1.00
	Total	37.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D8.1.1	Show cases planning	4	6.00	R	PP	34
D8.1.2	Show cases report	4	18.00	R	PP	37
D8.2.1	End-User Validation	1	13.00	R	RE	37
		Total	37.00			

Description of deliverables

D8.1.1) Show cases planning: Show cases selected and detailed planning of workshops [month 34]

D8.1.2) Show cases report: Report compiling the feedback from workshops performing the show cases [month 37]

D8.2.1) End-User Validation: End-user feedback on show cases workshops and validation results of end-user requirements fulfilment. The report will propose also extensions, modifications and possible future research steps out of the ARUM project achievements from the end-user /industry perspective [month 37]

WT3:
Work package description

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS19	Number of show cases and target audience defined	1	28	Out of the use case definition the number of show cases in WP8 and target audience is defined

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP9	Type of activity [54]	OTHER
Work package title	Exploitation, Standardisation & Dissemination		
Start month	1		
End month	37		
Lead beneficiary number [55]	12		

Objectives

The overall objective of this WP is to ensure visibility and mid- and long-term exploitability of the project results, especially by means of dissemination and exploitation of the ARUM research findings across scientific and industrial communities. The WP is organized in four activities, implemented as Tasks. Specifically, Dissemination (Task 9.1) is focused on providing visibility and cross-sharing of the project results in the scientific community, the broader community of users and stakeholders, and other relevant FP7 projects. Standardisation (Task 9.2) is aimed at ensuring that the project's decisions are aligned to current developments in relevant standardization bodies and to pave the way for the wider adoption of ARUM achievements and maximization of its impact by means of feedback and contributions to the standardisation bodies. End-user training (Task 9.3) will assure the proper implementation of the project achievements within the ARUM end-user organisations, as well as their continuity. Finally, exploitation and IPR issues are dealt with by Task 9.4, fostering the exploitation of the project results beyond the project lifetime and targets and the management of intellectual property of the project results.

Description of work and role of partners

Task 9.1 Dissemination (Lead: TIE)
This task will disseminate ARUM research findings across scientific and FP7 communities, as well as industrial communities and general public. The specific sub-objectives are:
• To create a dissemination and collaboration plan (T9.1.1)
• To set up and maintain the project internal and external web portal (T9.1.2)
• To produce material and other assets which can be used for dissemination (T9.1.3)
• To provide general/media/industrial visibility and acceptance of the project results (white papers, publications, participation to conferences, workshops and panels) (T9.1.4)
• To disseminate ARUM research findings across scientific and FP7 communities (T9.1.5)
• To interact with other similar projects and engage in clustering (T9.1.6)
• To raise industrial awareness regarding the potential of ARUM technologies by running ARUM workshops (T9.1.7)
• To provide for setting-up, administering and maintaining the Living Lab, both during the project and beyond (T9.1.8)

In order to realize these objectives, the task will implement the following activities:
• T9.1.1 – Dissemination and collaboration plan – Sub-Lead TIE
To ensure a coordinated approach to dissemination, by month 6 a dissemination plan will be created. This plan will cover all elements of Task 9.1 and allocate specific responsibilities to engaged partners – for example, allocate one partner for a specific event, or a production of a leaflet. The plan will account for real priorities and resources available. This plan will be living and be updated at least once a year in M13 and M25. This task is in particular supported by the Deliverable D9.1-1.
At M13, M25 and M37 three "Dissemination Status and Content" Deliverables (D9.1-2-4) will be produced. Each will update the plan by identifying actions undertaken, issues arising, changes (e.g., in priority) and importantly the content which has been delivered from dissemination tasks T9.1.2-8.

• T9.1.2 – ARUM Web Portal – Sub-Lead ICCS
In the first months of the project a web portal will be set up to represent the project externally, allow interactions and to internally support project collaboration. The web portal will enable project results to be made public,

along with any other related information deemed appropriate. Project results do not only concern documentation (i.e., public deliverables, white papers, publications, etc.), but also software (based on the corresponding licensing scheme selected per software module), since an important result of the project will be the tools produced. The project web portal will also collect feedback from the scientific community, potential end-users and other industrial stakeholders. The web portal will be maintained throughout the lifetime of the project and beyond with at least 3 monthly updates of some kind to ensure it is fresh. The website will include content and access management for internal and external parties (e.g., ARUM Living Lab). The results of this (e.g., website summary, traffic statistics) will be reported in D9.1-*.

• T9.1.3 – Dissemination Material – Sub-Lead TIE
This subtask will produce general purpose dissemination material which will include a project leaflet, brochure on use cases, a white paper (s), a poster/banner and standard slide show presentations of various lengths. Where applicable they will be kept up to date during the project lifetime. The results of this (e.g., physical and copies of material) will be reported in D9.1-*.

• T9.1.4 – General, Industry and Media Dissemination – Sub-Lead EADs
This subtask will take care of electronic newsletters and press releases (at least one per year, including at start of the project), encouraging company press releases, as well as for the diffusion of the results through mass media and general press and domain specific communication channels of the industrial community (e.g., focused magazines). The results of this (e.g., newsletters, releases, conference reports) will be reported in D9.1-*.

• T9.1.5 – Scientific Dissemination – Sub-Lead ICCS
The project's achievements will be communicated to the scientific community by means of production of leading-edge research material suitable for publication in international journals, conferences and workshops (cf. Section B3.2). The track record of ARUM's academic and research partners promises a high impact publication activity. The results of this (e.g., papers produced, acceptance, conference reports) will be reported in D9.1-*.

• T9.1.6 – Liaison and Sharing within FP7 – Sub-Lead – TIE
This task fosters concertation activities with other relevant FP7 projects in order to ensure a higher scientific and technological impact of the ARUM findings and solutions, as well as to foster exploration of possible synergies and complementarities. The vast participation of the ARUM partners in other projects' consortia contributes towards this direction. In that respect, the ARUM project will always be present with its results and focused demonstrations in all workshops organized by these, as well as other, EU projects. Additionally, ARUM partners will participate in EU events that relate with the project's objectives, such as EC consultation meetings. Moreover, this task will pave the way for forming the group of projects and organisations that will make use of the ARUM Living Lab. The results of this (e.g., collaboration actions) will be reported in D9.1-*.

• T9.1.7 – ARUM Workshops – Sub-Lead UNIMAN
During each year of the project, and more comprehensively in the last year, a Workshop with potential future users, industrial stakeholders, and other relevant parties will be organized for discussing results of validation and assessment of ARUM, as well as for enhancing visibility of the Living Lab. To reach a broad but also specialized group of participants this Workshop will be coupled to an existing and well-known big conference, dealing with ARUM relevant issues. Representatives of the main ARUM target groups and experts important for ARUM will be invited to this Workshop. Primary outcomes of the Workshop will be:
o First year: Input to the requirements/scenarios and architecture discussion
o Second Year: Input to the ongoing developments
o Third Year: Invitation for a future-oriented evaluation of the ARUM systems

These inputs will include suggestions on further RTD tasks and exploitation of the Living Lab infrastructure. The third workshop will be more significant in size/approach to ensure that there is maximum exploitation and interaction potential. The results of this (i.e., workshop reports) will be reported in D9.1-*.

• T9.1.8 – Living Lab – Sub-Lead ICCS
The concept of a Living Lab has been introduced in ARUM fostering to allow the promotion and dissemination of ARUM results, not only during its lifetime, but also (and especially) beyond the end of the project. The Living Lab will comprise an environment devised for both internal and external use, enabling the use of software systems and functionalities developed within ARUM. The concept concerns the deployment of a software platform infrastructure, reflecting the ARUM test bed and providing a selected set of the underlying functionalities to its users (internal and external) for experimentation.

In this context, this task will deal with the overall strategy and issues related with setting-up, administering and maintaining the Living Lab in the long term, as a community-based system. Therefore, this task will define the approach to be adopted for putting in place an open environment and the associated access patterns. It will specify the functionalities to be offered, the procedures regulating the Living Lab access and usage, and will provide for the appropriate management of resources, for what concerns both its internal and external use (such as contracts between partners on frameworks of content sharing, elaboration and implementation of workflows, etc.). By the end of the first project year, the partner responsibilities will be defined, while decisions regarding practical issues will be made, such as the hosting partners of the Living Lab installations, the communication and cooperation patterns, etc.; they will be revised on a yearly basis, following the overall dissemination strategy, and will be documented in D9.1-*.
Finally, it should be mentioned that this task will investigate possible synergies with other projects, on the one hand for forming the group of potential users and, on the other hand, seeking cooperation with projects also deploying living lab infrastructures (e.g., FoFdation).

Task 9.2 Standardisation (Lead: ICCS)
Task 9.2 will ensure that the project's decisions are aligned to current developments in relative standardization bodies and will pave the way for the wider adoption of its achievements and maximization of its impact.

Content of work:
• To ensure compliance with international standards, as well as interoperability with associated products.
• To disseminate ARUM findings to the appropriate standardisation bodies, providing sound scientific ground for the evolution of current standards, as well as the development of new.
• To foster the standardisation of ARUM's innovations as appropriate.

In that respect, the task will pursue the following activities.
• Industrial Agents
This task will deal with the issues related with the standardisation of industrial agents. This consists in two different perspectives: on one hand, the industrial agent-based solutions developed by ARUM should fulfil the current related industrial (manufacturing) standards, such as IEEE FIPA (Foundation for Intelligent Physical Agents), IEC 61499, ISA 95, ISA 88, etc. On the other hand, the task will drive the introduction of new standards or influence the specifications of the existing standards. As an example of this last perspective, ARUM foresees collaboration with the IEEE FIPA standardisation body, in order for the latter to accommodate some particular requirements of agent technologies to be used in industrial applications. A prominent opportunity here concerns the establishment of standards for real time scheduling systems, including classes of agents and types of negotiations inside one system, as well as interoperation and negotiation patterns between multiple multi-agent schedulers in a holonic p2p platform.
In that respect, ARUM will benefit by the liaisons of its partners with the respective fora; for instance, it is noted here that Paulo Leitão (ARUM partner IPB) is the chair of the IEEE Industrial Electronics Society Technical Committee on Industrial Agents; therefore, direct cooperation between ARUM and the Committee's standardisation activities.

• Ontologies
ARUM proposes an ontology-driven approach in order to achieve its operational goals. In this context, a variety of ontologies will be developed by the project, along with the appropriate tools for their management and visualisation. Apart from the need for compliance to international standards, this creates potentials for contributing to standardisation initiatives related to ontologies, that will be investigated in the context of this task. For instance, an obvious target standardisation body is the World Wide Web Consortium (W3C); ARUM will propose and actively support the creation of a new Community or Business Group within W3C, for the development of ontological models pertaining to ARUM's activities and knowledge domains. In this context, it is of great interest to ARUM to foster the standardisation of ontological information models for the semantic description of sensor data collected from the workshops, along with the associated events, commands, messages, policies, etc.
It is noted that ARUM consortium brings in-house experience regarding ontologies standardisation; for instance, George Lioudakis (ARUM partner ICCS) is a rapporteur of the European Telecommunications Standards Institute (ETSI) Industry Specification Group (ISG), entitled "Measurement Ontology for IP Traffic" (MOI), dealing with standardisation of ontological data models for IP network monitoring and processing of related measurements.

• Communication and Interoperation Mechanisms

Work within this task will deal with activities related to business interoperability and communication, from a standardisation point of view, both in what concerns alignment with current standards and contribution to related activities. In fact, ARUM's approach for the platform and tools development, being grounded on concepts such as service-orientation, is bound to a variety of initiatives and standardisation bodies, including:
o Organization for the Advancement of Structured Information Standards (OASIS), e.g., the Technical Committees: Universal Business Language (UBL TC), Service-Oriented Architecture End-to-End Resource Planning (SOA-EERP TC), Semantic Execution Environment (SEE TC), Production Planning and Scheduling (PPS TC), Product Life Cycle Support (PLCS).
o Wide Web Consortium (W3C), notably all the W3C initiatives related with service-orientation and semantic enhancement of service descriptions.

Something that is of particular importance and should not be neglected here concerns interoperation and compliance with legacy systems that are typically used (also) in manufacturing processes, including ERP, CRM, MES, SCADA and DCS. Operationally, ARUM will address this need leveraging interoperable technologies (such as SOA) where appropriate (i.e., mostly at the interfaces level), as well as by complying with the standards regarding industrial automation, as described in the following.

• Industrial Automation
Overall, ARUM constitutes a project fostering leveraging automation in the manufacturing process.
In ANSI/ISA95 terms, the technologies that ARUM puts in place, especially the network of intelligent nodes—agents, are positioned mostly —but not exclusively— at Level 3. In that respect, interoperability at this level is a priority for ARUM which, however, will target compliance also with standards referring to the other levels. Therefore, ARUM will seek compliance with all standards pertaining to (intelligent) manufacturing and industrial operation in general, following the requirements for enterprise reference architectures specified in ISO 15704 and regarding frameworks, languages and modules. Nevertheless, certain ARUM aspects go up to Level 4 (for supporting integration with ERP and warehouse systems), as well as down to Level 2. Therefore, ARUM compliance goals will also concern standards such as IEC/ISO 62264 (for enterprise control systems integration), ISO/IEC 15288 (regarding lifecycle management), ISO 15531 (for manufacturing management data exchange), etc.

Task 9.3 End-User Training (Lead: AIB)
To take care of proper internal knowledge sharing, in terms of appropriately training the ARUM tools internal users within the project consortium, thus anticipating sound implementation of workflows leveraging ARUM achievements, as well as their continuity and viability.

Content of work:
• To put in place sound and well-tailored training plans.
• To provide consistent and useful training material.
• To perform the training and evaluate its results.

In that respect, the task will pursue the following activities:

• Identification of the trainers and trainees across the ARUM partners, especially from the industry, but also academy, research and technology stakeholders.
• Establishment of a general framework for the performance of training within ARUM.
• Provision of the training material and documentation.
• Exploitation of the full potential for controlled hands-on training performance, leveraging all available technical tools.
• Organisation of the appropriate series of courses and internal workshops, with a significant hands-on approach.
• Evaluation of the training results.

Task 9.4 Exploitation & Intellectual Property (Lead: EADS)
To ensure the exploitation of the project results beyond the project lifetime and targets.

Content of work:
• To investigate the link between technical results and business approaches and plans.
• To migrate of the project achievements to the production environments of the industrial organisations.
• To investigate the potentials and the rapid commercialisation of the ARUM technological results.

More specifically, within this task, the following activities will take place.

• Exploitation Plans and Business Strategies
The work within this task will concern the development of the exploitation plans of ARUM partners, in accordance with their profiles and interests, leading to the identification of sound business opportunities and development strategies. In that respect, this task will perform initial analyses of the marked contexts regarding ARUM solutions (agents, ontologies, tools, etc.) and will investigate the maturity of markets and technologies, as well as the competition. Moreover, the business and technical risks and threats will be explored.

• Industrial Exploitation
This task's work will put focus on the migration of the project achievements to the production environments of the industrial stakeholders that comprise the ARUM consortium. The starting point will be the outcome of WP1 and the identification of the operational needs at the strategic, tactical and operative levels. This will result in detailed plans regarding the potential to improve, replace or disrupt the existing business processes for ramp-up management and manufacturing automation.

• Exploitation by Technology Stakeholders and Researchers
This task will identify the potential exploitation routes for the ARUM findings and developed technologies. Having as starting point the outcome of Exploitation Plans and Business Strategies, a deeper analysis of the business value will take place, resulting in the suitable business models. In that respect, this task will perform: detailed market analyses; feasibility studies; identification of competing products and services; identification of risks and threats; estimation of short- and long-term market size and revenue; viability studies.
The work will not concern solely the manufacturing domains studied within ARUM (via the scenarios), but will span across a broad spectrum of industrial applications and beyond.
It is noted that ARUM partners SMRT and CER represent approximately half of the commercial European market for Multi-Agent Systems, thus anticipating rapid commercialisation of the project results, especially with respect to this domain.
On the other hand, using the same approach, the university partners and research institutes will investigate the potentials of commercialising their work within ARUM, e.g., by means of spin-offs and provision of consulting services. However, the exploitation bottom-line and most opportunities for the universities and research institutes stem from the great chance provided by ARUM to continue and extend their research and publication activities and support the execution of PhD and MSc theses, to enhance their internal know-how, as well as to transfer the findings of the project to their educational activities.

• Intellectual Property Rights
Due to the innovation of the results expected to comprise the ARUM outcome, it is possible that partners will generate Intellectual Property that has to be protected through patents for their exploitation outside of the project with appropriate licensing. Moreover, the development of software systems will take place within ARUM, in terms of the platform and the corresponding tools for automated control and optimisation; different software modules, developed by different project partners, in cooperation or not, will eventually fall under different licensing schemes. Thus, part of the work towards exploitation of the project results will concern the management of Intellectual Property Rights already from the beginning of the project and during its whole lifetime.

The starting point will be the related clauses of the Consortium Agreement, following DESCA, to be signed by the ARUM partners at the beginning of the project; this will be completely in-line with Annex II of the FP7 Model Grant Agreement, as far as the corresponding issues of ownership, protection and access rights are concerned. Besides these primitives, ARUM partners will consider and devise concrete IPR provisions at every major milestone of knowledge production and release, as well as software development, including design and development cycle start and end.

Furthermore, the IPR provisions of the Consortium Agreement will be particularised and concretised during the project, when the ARUM components and their dependencies will be more clear. In that respect, at the end of the first project year, a Deliverable (D9.4-1) will summarise the results of an internal workshop that will take place along with a plenary meeting. The aim of the workshop will be to identify the exploitable foreground project results and their dependencies, along with the associated beneficiaries and their rights as well as responsibilities, to determine the licensing strategy and to accordingly refine the IPR rules and provisions. In any case, the principles of fairness and proportionality will govern all IPR decisions.

Finally, it is to be noted that, when necessary, the ARUM partners will make use of the services of the European Commission's IPR Helpdesk.

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	6.00
2	AIB	5.00
3	CER	7.00
4	MGS	8.00
5	TIE	11.00
6	SMRT	13.00
7	ALM	5.00
8	CUAS	8.00
9	P3	2.00
10	UNIMAN	9.00
11	IPB	10.00
12	ICCS	15.00
13	CTU	5.00
14	UNIHA	3.00
	Total	107.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D9.1.1	Dissemination and Collaboration plan	5	8.00	R	RE	7
D9.1.2	Project web page, project description, leaflet, use case brochure, poster and project slide show	5	10.00	O	PU	13
D9.1.3	Dissemination Status and Content	5	10.00	R	RE	25
D9.1.4	Dissemination Status and Content	5	9.00	R	RE	37
D9.1.5	Living lab strategy	12	3.00	R	RE	13
D9.1.6	Living lab	12	6.00	O	PU	37
D9.1.7	Final ARUM dissemination workshop scope and objectives plan	12	2.00	R	RE	25
D9.2.1	Standardisation	12	19.00	R	PU	37
D9.3.1	End-User Training	2	19.00	R	PP	37
D9.4.1	IPR Specification Report and Exploitation Plan	1	7.00	R	RE	13
D9.4.2	Intermediate Exploitation Report	1	7.00	R	RE	25
D9.4.3	Final Exploitation Report	1	7.00	R	RE	37

WT3:
Work package description

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
		Total	107.00			

Description of deliverables

D9.1.1) Dissemination and Collaboration plan: This document will detail the expected dissemination and collaboration actions, their priorities, responsibilities and outcomes. It will be a living document, updated every 6 months, to guide the project's awareness and interaction program [month 7]

D9.1.2) Project web page, project description, leaflet, use case brochure, poster and project slide show: First set of dissemination material, especially the project web page, project description, leaflet, use case brochure, poster and project slide show. In addition the D9.1-1 deliverable will be updated with the latest status of each action and if applicable the content produced. This deliverable will also report on the first year activities and each 6 months there will be an update [month 13]

D9.1.3) Dissemination Status and Content: As per D9.1-2 but 25 month version (End of 2nd year) [month 25]

D9.1.4) Dissemination Status and Content: As per D9.1-2 but 37 month version (End of the project) [month 37]

D9.1.5) Living lab strategy: The living lab strategy for ARUM has to be defined until M13 and then further implemented along the project lifetime. D9.1-6 will comprise the actual ARUM Living Lab, along with the associated documentation. [month 13]

D9.1.6) Living lab: The living lab strategy for ARUM has to be defined until M13 and then further implemented along the project lifetime. D9.1-6 will comprise the actual ARUM Living Lab, along with the associated documentation. [month 37]

D9.1.7) Final ARUM dissemination workshop scope and objectives plan: The final dissemination event of ARUM has to be scoped and objectives and addresses auditorium has to be defined. [month 25]

D9.2.1) Standardisation: This document will provide a report on the standardisation activities performed during the project, as well as the plans for further standardisation after the project's duration, following the work base set before. [month 37]

D9.3.1) End-User Training: This deliverable will document the training activities carried out within the project, reporting the means leveraged for internal knowledge dissemination with respect to the ARUM users. [month 37]

D9.4.1) IPR Specification Report and Exploitation Plan: This document will report the IPR issues and exploitation plans, following a respective workshop to be carried out among the project partners. The deliverable will concern the identification of the exploitable foreground project results and their dependencies, the associated beneficiaries and their rights as well as responsibilities, and the determination of the licensing strategy, whereas the IPR rules and provisions will be accordingly refined. [month 13]

D9.4.2) Intermediate Exploitation Report: This document will provide an intermediary report on exploitation issues, as well as a refinement of IPR, if necessary. It will in particularly focus on the identification of exploitable foreground results, potential markets, benefits, competition, business models, etc. [month 25]

D9.4.3) Final Exploitation Report: This document will refine D9.4.-2, providing the final exploitation report at the end of the project. [month 37]

WT3:
Work package description

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS3	EAB candidate list	1	7	List of EAB members established and ready for invitation
MS5	Living lab approach and collaboration strategy with other FP7 projects defined	12	13	Collaboration with FoFdation and other FP7 projects and the living lab approach is defined
MS6	IPR strategy defined and dissemination status of deliverables revised	1	13	IPR strategy and exploitation plan available
MS15	Project closure	1	37	Project end
MS17	ARUM final dissemination workshop plan	12	25	The final dissemination event of ARUM, the scope and objectives are defined
MS20	Scope, location and dates of dissemination workshops defined	12	13	ARUM dissemination workshops along the project are scoped and scheduled and location is defined

WT3:
Work package description

Project Number [1]	314056	Project Acronym [2]	ARUM

One form per Work Package

Work package number [53]	WP10	Type of activity [54]	MGT
Work package title	Overall project management		
Start month	1		
End month	37		
Lead beneficiary number [55]	1		

Objectives

To manage and coordinate the project to a high standard: management activities will be carried out according to chapter 2.1 strategies, organizations , specifications and rules.

Description of work and role of partners

Task 10.1: Overall Project Management (Lead: EADS)
This task will be performed by the ARUM project coordinator and includes all project management actions needed to perform the project.

Content of work:
• Acting as the link between the EC and the project contractors for technical, financial and administrative issues.
•Issue of a consortium Agreement prior to project grant Agreement and maintenance of that consortium Agreement throughout the project life.
•Management of the Grant Agreement
•Organisation and chair of all Project Management Board (PMB) meetings, with preparation of agendas and minutes.
•Establish the work of the technical management board (lead by CER)
•Select and invite externals (end-user) for the External Advisory Board (EAB) and establish the terms of reference (ToR)
•Propose and disseminate templates for progress and management report
•Collation of Progress Reports and Management Reports, and Final Progress and Management Reports in line with EC requirements
•Monitoring of the progress claimed by partners in informal reports and in the Progress and Management reports against Milestone and Deliverable plans and, in conjunction with the PMB, planning of corrective action where required
•Monitoring of financial and manpower budgets and spending with corrective action being planned in instances of under or overspend.
•Collation and submission of financial statements and corresponding audit certificates for all contractors
•Receipt of all payments made by EC to contractors and appropriate distribution of these funds to contractors without unjustified delay
•Aim to ensure successful collaboration and aim to quick resolution of any difficulties or disputes
•Monitor the risk assessment and mitigation process
•Definition of rules for collaboration

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	EADS	22.00
	Total	22.00

WT3:
Work package description

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D10.1.1	Project Management Plan	1	1.00	R	CO	1
D10.1.2	EAB candidate list	1	1.00	O	CO	7
D10.1.3	EAB and ToR are established	1	2.00	O	CO	12
D10.1.4	Management report n°1	1	6.00	R	CO	13
D10.1.5	Management report n°2	1	6.00	R	CO	25
D10.1.6	Management final report	1	6.00	R	CO	37
		Total	22.00			

Description of deliverables

D10.1.1) Project Management Plan: The project management plan will describe in detail the management elements, rules and principles for ARUM and has to be available following the kick-off meeting to all partners. Major templates and other means for communication and documentation the project progress to PM will be included [month 1]

D10.1.2) EAB candidate list: EAB candidate list with potential members is compiled and will be discussed with partners and commission [month 7]

D10.1.3) EAB and ToR are established: EAB and ToR are established [month 12]

D10.1.4) Management report n°1: Reporting on project progress [month 13]

D10.1.5) Management report n°2: Reporting on project progress [month 25]

D10.1.6) Management final report: Reporting on project progress [month 37]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS3	EAB candidate list	1	7	List of EAB members established and ready for invitation
MS4	EAB and ToR established	1	12	EAB members selected and invited and ToR established
MS15	Project closure	1	37	Project end

WT4:
List of Milestones

Project Number [1]	314056	Project Acronym [2]	ARUM

List and Schedule of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS1	ARUM requirements management established	WP1	1	4	Requirements management software selected and available to all partners
MS2	End-user requirements defined	WP1, WP2	1	7	Availability of requirements and use case definition
MS3	EAB candidate list	WP9, WP10	1	7	List of EAB members established and ready for invitation
MS4	EAB and ToR established	WP10	1	12	EAB members selected and invited and ToR established
MS5	Living lab approach and collaboration strategy with other FP7 projects defined	WP9	12	13	Collaboration with FoFdation and other FP7 projects and the living lab approach is defined
MS6	IPR strategy defined and dissemination status of deliverables revised	WP9	1	13	IPR strategy and exploitation plan available
MS7	Specification phase completed	WP3, WP4, WP5	3	15	Availability of all specifications
MS8	Use case definition finished, use case #3 scope and size specified	WP2	9	13	Use cases defined and decision on use case #3 (domain, case study, simulation, etc.) is made
MS9	1st Software release (tools, architecture); business strategies definition 1st draft	WP3, WP4, WP5	3	18	Methods, Tools, Architecture 1st release available
MS10	2nd Software release (tools, architecture); business strategies definition 2nd draft	WP3, WP4, WP5	3	25	Methods, Tools, Architecture 2nd release available
MS11	Software final releases, business strategies finalized and reviewed	WP3, WP4, WP5	3	28	Methods, Tools, Architecture final release available and reviewed
MS12	ARUM solution integrated	WP6	5	31	ARUM solution available
MS13	ARUM requirements finalized	WP1	1	28	end-user requirements document final release available

WT4:
List of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS14	ARUM solution first integration release	WP6	5	28	ARUM solution first draft integration available
MS15	Project closure	WP9, WP10	1	37	Project end
MS16	ARUM trails objectives and focus	WP2, WP7	1	23	ARUM trails focus and objectives defined
MS17	ARUM final dissemination workshop plan	WP9	12	25	The final dissemination event of ARUM, the scope and objectives are defined
MS18	Participants for target workshops selected	WP2, WP7	1	18	Participants for target WS in WP7 (ARUM demonstrations) selected
MS19	Number of show cases and target audience defined	WP2, WP8	1	28	Out of the use case definition the number of show cases in WP8 and target audience is defined
MS20	Scope, location and dates of dissemination workshops defined	WP9	12	13	ARUM dissemination workshops along the project are scoped and scheduled and location is defined

WT5:
Tentative schedule of Project Reviews

Project Number [1]	314056	Project Acronym [2]	ARUM

Tentative schedule of Project Reviews

Review number [65]	Tentative timing	Planned venue of review	Comments, if any
RV 1	6	Munich	1st technical review
RV 2	14	NAN	1st annual review
RV 3	18	NAN	2nd technical review (if needed)
RV 4	25	NAN	2nd annual review
RV 5	31	NAN	3rd technical review (if needed)
RV 6	37	Hamburg	final review

WT6:
Project Effort by Beneficiary and Work Package

Project Number [1]	314056	Project Acronym [2]	ARUM

Indicative efforts (man-months) per Beneficiary per Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	WP 7	WP 8	WP 9	WP 10	Total per Beneficiary
1 - EADS	11.00	19.00	8.00	4.00	5.00	6.00	16.00	3.00	6.00	22.00	100.00
2 - AIB	8.00	9.00	2.00	0.00	0.00	0.00	8.00	4.00	5.00	0.00	36.00
3 - CER	2.00	4.00	4.00	27.00	80.00	15.00	7.00	4.00	7.00	0.00	150.00
4 - MGS	6.00	14.00	4.00	5.00	2.00	2.00	15.00	8.00	8.00	0.00	64.00
5 - TIE	6.00	7.00	0.00	38.00	0.00	12.00	6.00	1.00	11.00	0.00	81.00
6 - SMRT	9.00	2.00	2.00	51.00	58.00	10.00	9.00	5.00	13.00	0.00	159.00
7 - ALM	3.00	4.00	0.00	15.00	25.00	6.00	9.00	2.00	5.00	0.00	69.00
8 - CUAS	4.00	14.00	6.00	0.00	20.00	3.00	8.00	1.00	8.00	0.00	64.00
9 - P3	15.00	16.00	25.00	0.00	0.00	0.00	9.00	1.00	2.00	0.00	68.00
10 - UNIMAN	3.00	0.00	8.00	26.00	14.00	6.00	1.00	5.00	9.00	0.00	72.00
11 - IPB	2.00	0.00	2.00	20.00	26.00	4.00	4.00	1.00	10.00	0.00	69.00
12 - ICCS	2.00	2.00	3.00	27.00	6.00	6.00	5.00	1.00	15.00	0.00	67.00
13 - CTU	3.00	4.00	2.00	15.00	34.00	5.00	3.00	1.00	5.00	0.00	72.00
14 - UNIHA	2.00	22.00	10.00	8.00	12.00	7.00	6.00	0.00	3.00	0.00	70.00
Total	76.00	117.00	76.00	236.00	282.00	82.00	106.00	37.00	107.00	22.00	1,141.00

WT7:
Project Effort by Activity type per Beneficiary

Project Number [1]	314056	Project Acronym [2]	ARUM

Indicative efforts per Activity Type per Beneficiary

Activity type	Part. 1 EADS	Part. 2 AIB	Part. 3 CER	Part. 4 MGS	Part. 5 TIE	Part. 6 SMRT	Part. 7 ALM	Part. 8 CUAS	Part. 9 P3	Part. 10 UNIMAN	Part. 11 IPB	Part. 12 ICCS	Part. 13 CTU	Part. 14 UNIHA	Total
1. RTD/Innovation activities															
WP 1	11.00	8.00	2.00	6.00	6.00	9.00	3.00	4.00	15.00	3.00	2.00	2.00	3.00	2.00	76.00
WP 2	19.00	9.00	4.00	14.00	7.00	2.00	4.00	14.00	16.00	0.00	0.00	2.00	4.00	22.00	117.00
WP 3	8.00	2.00	4.00	4.00	0.00	2.00	0.00	6.00	25.00	8.00	2.00	3.00	2.00	10.00	76.00
WP 4	4.00	0.00	27.00	5.00	38.00	51.00	15.00	0.00	0.00	26.00	20.00	27.00	15.00	8.00	236.00
WP 5	5.00	0.00	80.00	2.00	0.00	58.00	25.00	20.00	0.00	14.00	26.00	6.00	34.00	12.00	282.00
WP 6	6.00	0.00	15.00	2.00	12.00	10.00	6.00	3.00	0.00	6.00	4.00	6.00	5.00	7.00	82.00
Total Research	53.00	19.00	132.00	33.00	63.00	132.00	53.00	47.00	56.00	57.00	54.00	46.00	63.00	61.00	869.00
2. Demonstration activities															
WP 7	16.00	8.00	7.00	15.00	6.00	9.00	9.00	8.00	9.00	1.00	4.00	5.00	3.00	6.00	106.00
Total Demo	16.00	8.00	7.00	15.00	6.00	9.00	9.00	8.00	9.00	1.00	4.00	5.00	3.00	6.00	106.00
3. Consortium Management activities															
WP 10	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.00
Total Management	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.00
4. Other activities															
WP 8	3.00	4.00	4.00	8.00	1.00	5.00	2.00	1.00	1.00	5.00	1.00	1.00	1.00	0.00	37.00
WP 9	6.00	5.00	7.00	8.00	11.00	13.00	5.00	8.00	2.00	9.00	10.00	15.00	5.00	3.00	107.00
Total other	9.00	9.00	11.00	16.00	12.00	18.00	7.00	9.00	3.00	14.00	11.00	16.00	6.00	3.00	144.00

WT7:
Project Effort by Activity type per Beneficiary

Total	100.00	36.00	150.00	64.00	81.00	159.00	69.00	64.00	68.00	72.00	69.00	67.00	72.00	70.00	1,141.00

WT8:
Project Effort and costs

Project Number [1]	314056	Project Acronym [2]	ARUM

Project efforts and costs

Beneficiary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)						Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Total costs	
1	EADS	100.00	952,199.00	9,000.00	89,000.00	596,091.00	1,646,290.00	1,089,501.00
2	AIB	36.00	414,401.00	0.00	18,000.00	13,007.00	445,408.00	277,276.00
3	CER	150.00	859,500.00	6,000.00	60,787.00	552,172.00	1,478,459.00	1,125,412.00
4	MGS	64.00	590,495.00	3,000.00	27,000.00	31,498.00	651,993.00	402,710.00
5	TIE	81.00	716,610.00	16,000.00	90,000.00	424,764.00	1,247,374.00	964,024.00
6	SMRT	159.00	437,250.00	6,000.00	45,000.00	289,350.00	777,600.00	598,400.00
7	ALM	69.00	517,500.00	7,500.00	35,000.00	331,500.00	891,500.00	667,300.00
8	CUAS	64.00	352,000.00	3,000.00	34,000.00	231,600.00	620,600.00	476,000.00
9	P3	68.00	638,520.00	3,000.00	54,250.00	138,554.00	834,324.00	437,364.00
10	UNIMAN	72.00	501,840.00	3,000.00	41,000.00	325,704.00	871,544.00	696,052.00
11	IPB	69.00	255,300.00	0.00	29,000.00	170,580.00	454,880.00	356,320.00
12	ICCS	67.00	388,600.00	3,000.00	37,000.00	255,360.00	683,960.00	541,640.00
13	CTU	72.00	288,000.00	3,000.00	28,400.00	189,840.00	509,240.00	390,680.00
14	UNIHA	70.00	343,000.00	3,000.00	48,100.00	234,660.00	628,760.00	467,000.00
Total		1,141.00	7,255,215.00	65,500.00	636,537.00	3,784,680.00	11,741,932.00	8,489,679.00

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It cannot be changed unless agreed so during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

53. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

54. Type of activity

For all FP7 projects each work package must relate to one (and only one) of the following possible types of activity (only if applicable for the chosen funding scheme – must correspond to the GPF Form Ax.v):

• **RTD/INNO =** Research and technological development including scientific coordination - applicable for Collaborative Projects and Networks of Excellence

• **DEM =** Demonstration - applicable for collaborative projects and Research for the Benefit of Specific Groups

• **MGT =** Management of the consortium - applicable for all funding schemes

• **OTHER =** Other specific activities, applicable for all funding schemes

• **COORD =** Coordination activities – applicable only for CAs

• **SUPP =** Support activities – applicable only for SAs

55. Lead beneficiary number

Number of the beneficiary leading the work in this work package.

56. Person-months per work package

The total number of person-months allocated to each work package.

57. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

58. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

59. Milestone number

Milestone number:MS1, MS2, …, MSn

60. Delivery date for Milestone

Month in which the milestone will be achieved. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

61. Deliverable number

Deliverable numbers in order of delivery dates: D1 – Dn

62. Nature

Please indicate the nature of the deliverable using one of the following codes

R = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

63. Dissemination level

Please indicate the dissemination level using one of the following codes:

• **PU =** Public

• **PP =** Restricted to other programme participants (including the Commission Services)

• **RE =** Restricted to a group specified by the consortium (including the Commission Services)

• **CO =** Confidential, only for members of the consortium (including the Commission Services)

• **Restreint UE =** Classified with the classification level "Restreint UE" according to Commission Decision 2001/844 and amendments

• **Confidentiel UE =** Classified with the mention of the classification level "Confidentiel UE" according to Commission Decision 2001/844 and amendments

• **Secret UE =** Classified with the mention of the classification level "Secret UE" according to Commission Decision 2001/844 and amendments

64. Delivery date for Deliverable

Month in which the deliverables will be available. Month 1 marking the start date of the project, and all delivery dates being relative to this start date

65. Review number

Review number: RV1, RV2, ..., RVn

66. Tentative timing of reviews

Month after which the review will take place. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

67. Person-months per Deliverable

The total number of person-month allocated to each deliverable.

Grant Agreement for:Collaborative Project – Large Scale Integrated Project

PART B

Project acronym:	ARUM
Project full title:	ARUM – Adaptive Production Management
Grant agreement number:	314056
Date of preparation of Annex 1:	18-07-2013
Date of approval of Annex 1 by the Commission:	

Table of Contents

Inhalt

B1. Concept and objectives, progress beyond state-of-the-art, S/T methodology and work plan

B 1.1 Concept and project objective(s)

Concept and objectives

Context

Problem of Production Ramp-Up: Aviation news frequently report on delayed or even failed aircraft ramp-ups in these days. Affected are both market leaders Boeing and Airbus. Aircrafts in particular represent highly customized and complex products. The successful ramp-up of commercial aircraft is threatened by a variety of risks. These risks cause a significant reduction of the targeted production rate (see Figure 1). Exploding costs are the result.

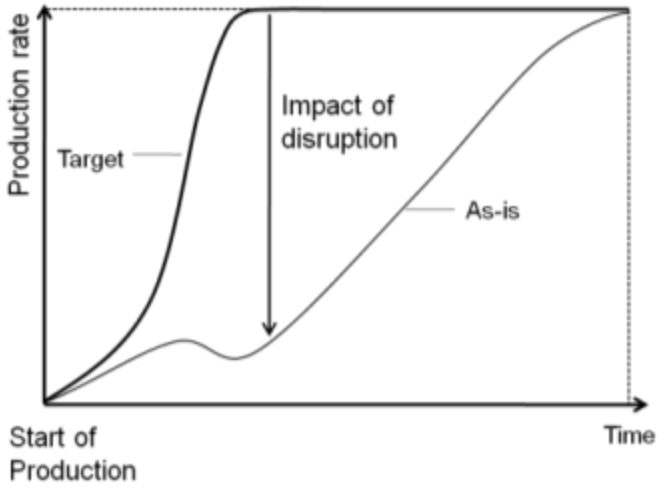


FIGURE 1: PRODUCTION RATE TARGETS VERSUS REALITY IN EARLY PRODUCTION PHASE

The growing competition and a shorter innovation cycle lead to a rising number of ramp-ups. Besides the complexity of the product aircraft itself future ramp-ups face further challenges. The transition from single to series production and new customization strategies are indispensible in order to reach high production rates.

A good example for that challenge is the Boeing 787 production ramp-up. The initial planning for the Boeing 787 ramp-up was the start of production in 2008 and a very fast production ramp-up of up to 120 A/C per year. Reality proved their plans wrong (see Figure 2):

- Innovations requested by demanding customers were not handled appropriate and missing maturity was the result. The 787 was the first production composite airliner, with the fuselage assembled in one-piece composite barrel sections instead of the multiple aluminium sheets. Airbus will follow this composite example with the A350XWB
- Another novelty was the new supplier network. Boeing assigned its global subcontractors to do more assembly themselves and deliver completed subassemblies for final assembly. The intend was achieve a leaner and simpler assembly line and lower inventory, with pre-installed systems reducing final assembly time by three-quarters to three days. About 80% of the Boeing 787 is fabricated by outside suppliers, vs. 51% for existing Boeing planes. As a consequence suppliers struggled to meet Boeing's technological demands and ambitious production deadlines. Consequently Boeing bought one supplier e.g. Vought to regain control of complexity and

supplier.[1] Weight problems required redesign and more use of lighter titanium. Increasing costs for uncoordinated change management and materials were the result.

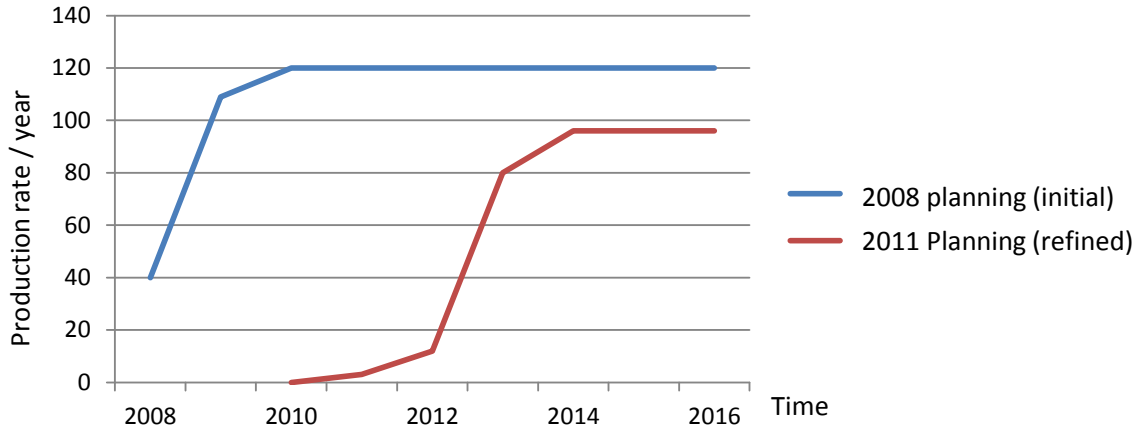


FIGURE 2: FIGURE 2: RAMP-UP PROCESS PLANNED AND REALIZED (BOEING 787)

All these risks occurred at Boeing even though simulation techniques were applied. Additionally the short supply of fasteners was not noticed in an early stage.[2] Development and ramp-up costs added up to 32 billion US$. To reach the break-even point at least 1100 aircraft need to be sold instead. Former programs with a lower technological level calculated 400.

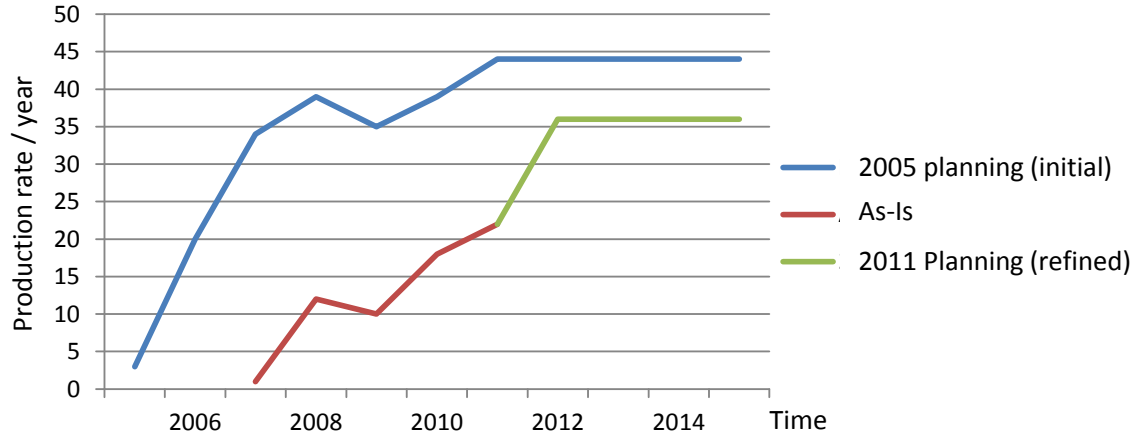


FIGURE 3: RAMP-UP PROCESS PLANNED AND REALIZED (AIRBUS A380)

Similar unpredictable problems occurred in the Airbus A380. The consequence was a delayed ramp-up of more than two years and a production rate which still is very much behind the expectations (see Figure 3).

[1] Sander, P.: Boeing sets deal to buy a dreamliner plant. Version: 2009. http://online.wsj.com/article/SB124696971307105465.html. The Wallstreet Journal.

[2] Figgen, A.: Der Schwierige Weg bis zum Erstflug. In: Aero International 4 (2009), S. 40–43

Problem of Small Lot Production: The permanent rising of sophisticated costumer demands in different branches justifies the small lot production. This trend is driven by the increasing competition in standard product markets especially from Asia. Therefore European companies more and more enter into the individual customer markets. So has the number of ships built in one series with identical design reduced from up to 10 ships (e.g. container, bulk carrier or ferries) in the 1980-90 down to four ships per series today. According to latest forecasts this number will shrink further on in the near future for European ship yards.

This trend will not only affect the effort in engineering individual ships for customers, also the effort in production planning and management will significantly increase3. Frequently occurring errors prove that product design, production lines, suppliers, IT or logistics are not ready at the very first products of the series. Late requests for change by customers are additional risks for this state of production. Experiences from a German shipyard4 have shown that within a typical ship production series (passenger/car ferries, RoRo vessels) finally the 3rd serial product achieves the expected level of planning, product maturity and manufacturing quality. In small lot production with four or less instances the resulting challenge is to enhance the understanding of risks, faster respond to unexpected events, to enrich the base of information for decision making, to detect early warning and to accelerate learning. And those processes still need to be managed economically. Therefore learning curve effects need to be exploited and decision support has to be optimized.

Small lot production in this context can be seen similar to the phase of production ramp-up. Ramp-up is the phase of transition between product development and the maximum capacity utilization. Thus like in small lot production the occurrence of unpredictable disruption is a common character in ramp-up too.

To handle those risks a new risk management approach is required. Risks do not happen once in a while, in the very beginning they occur on a daily base since every product is different. A detailed pre-planning to identify bottle necks before actual start of production is a key requirement for future complex production side with a high share of automated technologies. The development of mitigation strategies in a close collaboration with engineering and manufacturing is a fundamental aspect in the running process.

Needs in Manufacturing Management: Given the problems in ramp-up and small lot production an additional trend has to be observed in terms of:

- More variants and products in shorter sequence but also significant increase of automation, ICT controlled manufacturing systems and planning and control solutions
- Weak integration of engineering to production (horizontal) and enterprise ICT to shop floor automation and sensor level (vertical)

Consequently, future manufacturing needs to become a process of dynamic, event-sensitive operations, resource allocation, scheduling, optimization and controlling. Manufacturing management appears more and more to integrate and balance several factors, like quality, risks, costs and critical application time issues (Figure 4).

Today	Future
• Batch	• Real time
• Optimizer	• Manage trade offs
• Rules Engines	• Decision Making logic
• Constrains	• Cost / value equation
• Visualize	• Learn, adapt and forecast

[3] Today's production rates of up to 10 ships per year will lead to nearly doubled engineering effort for than four instead of two new ship series per year

[4] FGS shipyard in Flensburg, will become External Advisor in the ARUM project

FIGURE 4: 1 MODERN TRENDS IN INTELLIGENT MANUFACTURING

Nowadays many companies suffer from a lack of agility to respond to late requests for changes by customers. Also it is hard to react on immature components. This means problems like this cannot be mitigated immediately and cause significant delays until a response from engineering or supplier site takes part. This proves that capacity planning in the future needs to be handled more flexible.

Finally lacking knowledge of OEMs, suppliers, engineering, but also of customers regarding the use of specification and the product are major sources of failures. Thus boosting the learning-curves is a major objective which needs to be tackled.

Complexity for modern enterprises is caused by:

- On-going innovations and changes of products, technologies, equipment, toolsets, etc;
- Large size of production workshops (for example, airspace enterprise has more than 40 workshops coordinating their plans, generates more than 1000 orders per day per one workshop, has more than 1000 suppliers, more than 150 workers in one workshop, etc);
- Many unpredictable events (demand and resource fluctuations, order cancelled, resource unavailable, maturity, etc.);
- Real-time resource allocation, scheduling, optimization and control with shrinking time windows and different strategies (as soon as possible, as cheap as possible, VIP client, etc.);
- Interdependent schedules of many workshops (mechanic workshop, assembling workshop, etc.);
- Intensive use of sensors and robotic multi-functional units which make enterprises more flexible and operative to market changes;
- Numerous constraints on products, operations, workers skills, equipment, materials, compatibility, etc.;
- Individual agreements with major clients, suppliers, workers, etc.

Thus key requirements of modern manufacturing include support of complexity and variety of products, scalability, integrated control of factory assets, factory and workshop level optimization of production, production automation and control, resource and cost effective aggregation of information across legacy systems (ERP, MES, SCADA, DCS), flexible, fast, service-oriented model, integrating networks.

The AIAG FoF PPP[5] has stated in this context: *"Future production sites for a large variety of sophisticated products will offer flexible, short cycle time and variability controlled manufacturing capability. These manufacturing approaches ensure energy-efficient, reliable and cost effective production as well as production set-up/ramp-up with reduced cost and time through lean and simpler ICT."*

The FoF roadmap[6] therefore supporting ICT-enabled solutions for intelligent manufacturing focusing on (Digital Factories, Smart Factories):

- Integrated automation and control systems from Manufacturing Execution Systems (MES) down to shop floor level (vertical integration)
- Integration of design of products and manufacturing systems by means of data integration, simulation and knowledge management / knowledge processing from product concept level down to manufacturing and beyond (horizontal integration)

[5] AIAG FoF PPP: Factory of the Future PPP: Strategic Multi-annual Roadmap (2010), S. 12

[6] AIAG FoF PPP: Factory of the Future PPP: Strategic Multi-annual Roadmap (2010), S. 12ff

- Cooperative control systems within scalable factory solutions using modern architectures (e.g. service oriented architectures - SOA) incorporating legacy systems (e.g. by means of migration, transition)

Objectives and ARUM approach

Within the above described context the **industries objective** for the ARUM project are strategies and novel ICT solutions for handling, management and overcome the following challenges:

- Increasing risks for product immaturity and production disruptions due to high time to market pressure
- Complex and highly customized products for small production series
- Significant demand for automation and ICT controlled manufacturing systems and planning & control
- Weak integration of engineering to production (horizontal) and enterprise ICT to shop floor automation (vertical)

Therefore the main objective of the ARUM solution is to **significantly improve the operational and economic performance** of production ramp-ups and small lot productions by delivering novel strategies, ICT systems and tools for automation control and optimization to the industrial end-users.

The quantitative targets of ARUM to be demonstrated and benchmarked against existing stat of play are (Figure 5):

	Planning & testing costs	**Ramp-up costs**	**Ramp-up delay**	**Production volume in ramp-up**
Aircraft new product ramp-up	-10%	-30%	-30%	+15%
Aircraft system supply small lot production	-10%	-20%	-20%	+15%
Other sectors application (e.g. ship yard)	Costs -15%		-15%	-

FIGURE 5: QUANTITATIVE TARGETS

To accomplish these major objectives the **ARUM approach** includes the following four pillars which are essential for novel ICT-driven process automation and control solutions supporting the flexibility, autonomy and robust production ramp-up and small lot production:

1. Development of risk mitigation and management **strategies** for integrated control and dynamic optimization:
    - Risk reduction and mitigation strategies for planning phase of production ramp-up and small lot production (flexible versus robust production strategy and associated resource planning, shop floor layout, etc.)
    - Risk management strategies in real-time management of production ramp-up and small lot production (decision making logics)
    - Transfer of risk mitigation and management strategies into formal representation (ontologies for knowledge representation, decision rules) for usage in knowledge-processing tools supporting automated control and optimization

2. Development of **ICT systems** for integrated control and dynamic optimization:
   - A scalable architecture based on open standards and able to integrate all levels of information systems from sensor peripheries to legacy systems and selected tools for added-value services
   - The basic platform for predictive and a real time automation control and optimization based on knowledge processing Multi Agent System (MAS) supporting the pre-planning and in production control and optimization
3. Development **tools** supporting integrated control and dynamic optimization of factory assets for production ramp-up and small lot production series of complex and highly customized products
   - Tools for added-value services like learning, quality control, risk- and cost-management and control of environmental footprints
   - In predictive mode the tools will supports the planning phase of a production system in accordance to most beneficial risk reduction and mitigation strategies
   - In real-time operations mode the tools will support dynamic, time-, cost- and risk-oriented re-planning of operations, the evaluation and mitigation / management of risks and the provision of information for engineering to alter design if required in case of immaturity or late requests for changes
4. **End-to-end integration** the ARUM solution with legacy systems and information aggregation across existing legacy systems and production levels

The top level requirement within FoF ICT call, to demonstrate the operational and economic benefits and applicability of ICT solutions (lean and simpler ICT) in industrial environment will be proven by multiple use cases (aircraft production ramp-up, small lot production of Aircraft Interior Equipment, small lot production of RoRo vessels). The ARUM solution will be benchmarked in real production environments for those use cases: Airbus aircraft production, MGS interior manufacturing and FGS shipyard manufacturing. The validation includes economic, operational and ecological assessment and an explicit end-user validation.

The further dissemination and exploitation of ARUM results is planned by means of a Living Lab approach. An ARUM lab test bed will be transferred at project end to academic partners for further use the infrastructure and ARUM results for other use cases of interested European researchers or industrial end-users.

ARUM scope: The ARUM project focuses on development of strategies, systems and tools supporting integrated control and dynamic optimization of factory assets for **production ramp-up and small batch production series** of **complex and highly customized products.** The solution will address the **pre-preparation and production phase (**ramp-up/ small batch production) and related tasks like strategic planning, risk assessment, integrated control and optimization in real time.

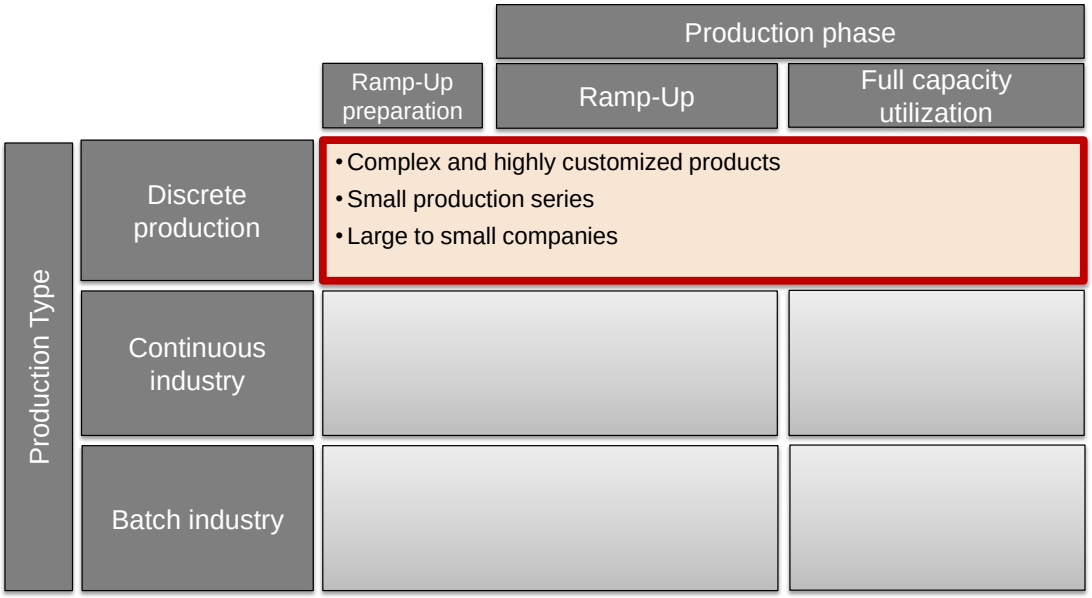


FIGURE 6: ARUM SCOPE

Therefore ARUM focuses on an end-to-end solution supporting the production management starting at ramp-up preparation (collaboration with engineering and production planning), while production ramp-up (or small lot production) and will link to the steady state / full capacity production management (see Figure 6).

ARUM solution shall be developed and implemented based on end-user requirements elicitation and validation of use cases within an real industrial environment, in which integration of all existing and novel manufacturing (management) systems and factors across all hierarchies and along all ramp-up and small lot production processes is pursued; development of a distributed Service Oriented Architecture –based Enterprise Service Bus enabling multi-scale and multi-level manufacturing management, and development of knowledge processing multi-agent systems bringing about the higher ramp-up and small lot production management performance levels.

ARUM as an Integrated Project will benefit from existing technologies, implemented functions and tools and capabilities coming from previous projects and integrate these elements into the novel ARUM solution. In addition dedicated R&T activities will be performed on adapting these technologies, functions and tools and capabilities.

1. End-User Requirements Elicitation

The project will be driven by end-users requirements and industrial use cases. Those end-user requirements and industrial use cases will be the baseline for implementation the novel ARUM solution and later on validation of performance in terms of operational and economic benefit. Two end-users are full partners of the consortium (AIB, MGS); both are part of the project core team.

The industrial use cases will address both areas of ARUM interest; the production ramp-up and the small lot production in different branches and at different sized companies (see Figure 7).

Use Case	Description
New Aircraft Program Ramp-Up	• **Product**: Commercial Aircraft, short range, approx.180 seats • Production rate / year (in steady state) up to 400 aircrafts, expected total series >5000 aircrafts • Big sized company, global distributed with complex supply chain • **Production process** will include automated aerostructure manufacturing,

Use Case	Description
	fuselage assembly, equipment installation and final assembly line (FAL). • Workshops are characterized by a number of manual, mechanical and automated tools are used and a variance of differently qualified stuff carries out a various jobs. • Engineering processes and production system planning with digital tools (commercial and proprietary) • Production processes are steered by work orders which are partly administrated by SAP or Airbus proprietary tools. • **Scenario to be validated**: Steep ramp-up the aircraft production to >100 / 1st year, 400 / 2nd year in combination with reduced lead times
Aircraft Interior Equipment Production (small lot production	• **Product:** Galley Insert: Induction Cooktop for Aircrafts • Small series of up to 8 inserts per year for specific customer • Small sized company, several component suppliers • **Production process** will include selected manufacturing facilities of major component suppliers and the final assembly and testing work stations for complete ship sets (number of galleys to be supplied into one aircraft). At most work stations a number of manual, mechanical and automated tools are used and a variance of differently qualified stuff carries out a various jobs. • Engineering processes and production system planning partially supported by ICT tools (commercial and proprietary) • The suppliers are controlled via work order referencing production drawings. The drawings are maintained inside the Microsoft Dynamics (form Navision) System. • The development phase and the production phase are very connected especially the timing when a product shall be shifted from development to production is extremely critical and affects in high number of disturbances • **Scenario to be validated**: Small 8 galley insert production
RoRO Vessels production (small lot production)	• **Product**: RoRo-Vessel, approx.14.000dwt capacity • Small series between 2 and maximal 8 ships • Medium sized company, global supply network but only small number of jobs, services and components are outsourced • **Production process** will include work stations for metal cut, block assembly, ship body assembly and equipment installation at slope and water side • Metal cut station is high automated, other production steps using of manual, mechanical and automated tools and variance of differently qualified stuff carries out a various jobs. • Engineering and production system planning and control by commercial and proprietary ICT tools • **Scenario to be validated**: Small 4 vessels production series

FIGURE 7: PLANNED ARUM USE CASES

The ARUM project follows the principles of **user-driven development** of systems. The involved industrial partners are well-experienced in development and implementation of user driven solutions following rules and methods of software engineering. ARUM will apply this systematic end-user driven approach for all technical elements to be developed. The end-user driven development process will start with the derivation of user requirements and will proceed in derivation of functional requirements. The specifications and later on the implemented technical solutions will be

validated against those requirements. ARUM will provide dedicated requirements management capabilities for that process across the whole project lifetime.

The evaluation of ARUM outcome will rely on **objective assessment methodology** and will strongly involve end-users. The success criteria for ARUM novel solutions will be quantitative measured by real advantages in operational and economic benefits against todays ICT solutions of industrial use case partners. For that a benchmarking approach will be used. The ARUM solution will be integrated on a lab test bed connected to the use case industrial environment and stimulated by simulation means. That ARUM test bed will follow a **Living Lab approach** and will be transferred at end of the project to public as part of the dissemination activities.

ARUM will develop specific models and key performance metrics for assessment the project performance improvements. This will allow the quantification the improvements in terms of de-risking the production ramp-up / small lot production but will also add indicators for economic and ecological impact and in terms of lean and easy use. The novel ICT solutions will be validated from end-users and assessed against those key performance metrics. The evaluation includes the demonstration of success critical functions in front of and with involvement of end users. End-user feedback and recommendations will be compiled into the assessment outcome.

2. Validation within Real Industrial Environment

ARUM solution has to demonstrate its advantages to today's automation control and optimization means for ramp-up and small lot production against real industrial environments as provided by industrial partners through their use cases. The concept behind will be the **ARUM test bed** that couples the ARUM solution (enterprise service bus, basic platform and additional tools) with **real industrial environment** and discrete event simulation based stimulus implementation of the use cases.

The discrete-event simulation will be used to identify the relevant parts of the manufacturing system depending of the use case of interest. The discrete-simulation model represents both the corresponding base system and base process. It includes the dynamic and stochastic behavior of the corresponding manufacturing system and process.

The center-point of the benchmarking architecture is a data-layer between the simulation package and the planning and control system. The planning and control system will be implemented as a distributed multi-agent-system. The data-layer contains the most important business objects like machines and jobs and their status and will enable also the access to data sources from real industrial environment. Notification functions will be used to update the objects of the data-layer in an event-driven manner. Databases can be used to make portions of the data-layer persistent.

The steering system is the simulation engine. The planning and control system, in ARUM the distributed multi-agent-system, will be used to generate planning and control instructions for the simulation model in a rolling horizon setting. For this, the simulation will be stopped, the multi-agent-system determines the instructions of interest based on the current data in the data-layer, send the instructions to the simulation model, and then the simulation continues.

The main advantage of this approach is given by the opportunity to assess the (unknown) performance of a new planning and control system in a rather realistic environment before the planning and control system is applied to the real manufacturing system. While the ARUM trails and

benchmarking campaigns parts of the simulation model will be replaced by operational information system like an MES and an ERP.

The overall setting for the benchmark using a Testbed coupled with real industrial environment and discrete event simulation based stimulus implementation of the use cases is shown in the Figure below.

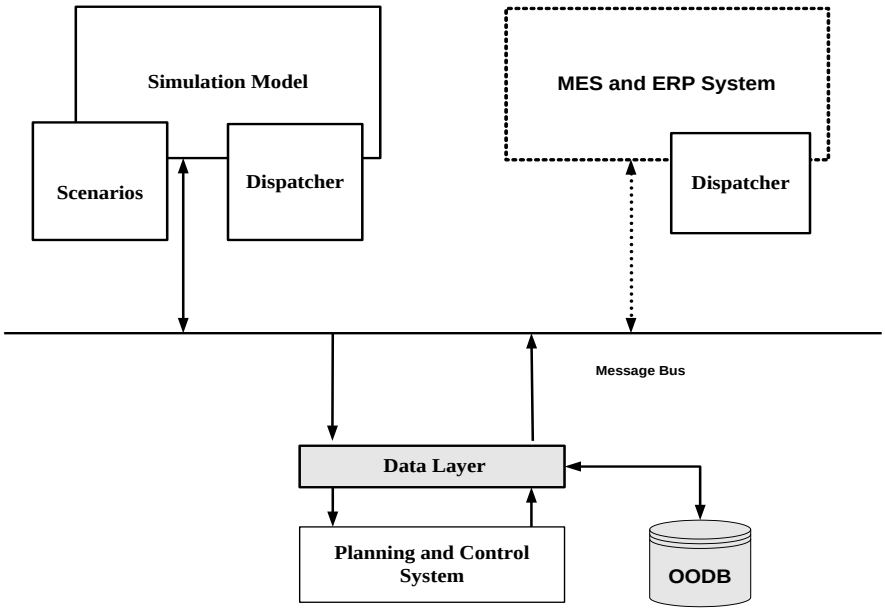


FIGURE 8: ARUM BENCHMARKING ARCHITECTURE [22]

3. Integration across all hierarchies and along all manufacturing processes

The ARUM solution will address the end-to-end integration from strategies to systems to tool (all control and optimization levels), the **vertical integration** from MES down to shop floor and **horizontal integration** from engineering to production system planning to ramp-up and steady state production processes. For that the envisaged technologies of distributed multi agent system within a holonic architecture have to integrate legacy systems, information aggregation from high level systems (MES, ERP, etc.) to factory floor automation (e.g. metal cut and assembly systems)

Manufacturing usually is distributed across a number of workshops, includes a variety of legacy systems and employs a mix of different strategic and tactical/operational tools. Comparing respective systems it becomes obvious that they include general as well as domain-specific properties and functionality.

The ARUM basic platform – based on proven state-of-art multi-agent technology structurally supports applicability to a wide spectrum of manufacturing systems, including variety of industries, variety of products manufactured by an individual factory (or firm), variety of volumes of manufacturing, as well as application-wide integration and automation of planning and control at any appropriate resolution of object (details) and time (density of unplanned events to be accommodated). If needed the same platform should operate in or very close to real-time.

In simulation mode the platform and tools allow producing events randomly or from history data as well as integrating with external sources like legacy systems or sensor environments via platform-wide bus. In real time platform and planning/scheduling tools can react on unpredictable events providing coordinated behavior of workshops.

Service-oriented modeling and intelligent algorithms / protocols provide effective and efficient solutions while balancing contradictive objectives.

The adaptive resource management system and tools facilitate data and knowledge aggregation and supports real time decision making processes on resource scheduling and optimization across different business SW systems of the value chain including product design, production lines, suppliers, IT or logistics – where time-criticality of the decision making is highly important.

The main goal of project is to show the operational and economic benefits of new **real time** ICT-driven approaches against today's **batch** process automation and control solutions. Its objectives contribute to the development of intelligent and scalable architectures for next-generation production automation with a strong focus on the ramp up phase and steady state production which require high adaptability, flexibility and reconfigurability of production processes.

The core innovative elements are centered around a multi-level distributed holonic architecture employing the intelligent enterprise service-based platform (i-ESB Platform). This platform provides a communication infrastructure, service-based interoperability and p2p networking environment for knowledge-based multi-agent scheduling and optimization tools. These tools provide real time decision making support, while working on the top of legacy systems including existing Enterprise Resource Planning, Warehousing, Manufacturing Execution, data collecting systems like SCADA or middleware for sensor peripheries, potentially knowledge management systems, etc.

The platform, system and tools will support scheduling and optimization on the level of workshops as well as on the level manufacturing enterprise as a whole.

Project will cover several use cases from different industrial sectors for which demonstration and benchmarking will be carried out, first of all, in airplane manufacturing.

4. SOA-based Enterprise Information Bus

The major disadvantage of the available state-of-the-art systems for resource allocation, scheduling, optimization and controlling in manufacturing is their limitation to a single workshop only. However, for simultaneous deployment at multiple sites of a manufacturing enterprise another level of scalability and performance is required.

Designed i-ESB Platform will enable the construction of **large-scale multi-level enterprise systems** for manufacturing. In our vision large-scale manufacturing systems will be organized as a **holonic networks** of real time schedulers of workshops (integrated with legacy systems in SOA/ESB) which can work as an autonomous internal or external services, communicate directly using p2p architecture and compete or cooperate in process of manufacturing providing event-triggered time critical, economy-driven and energy efficient decisions in real time.

The proposed approach goes beyond of the art with the idea of holonic networks of multi-agent workshops schedulers based on P2P (peer-to-peer) communications. Such network can showcase co-evolution of self-organized systems replacing traditional waterfall schemes with "master-slave" relations by autonomous and coordinated work of "equal to equal" schedulers (see Figure 9).

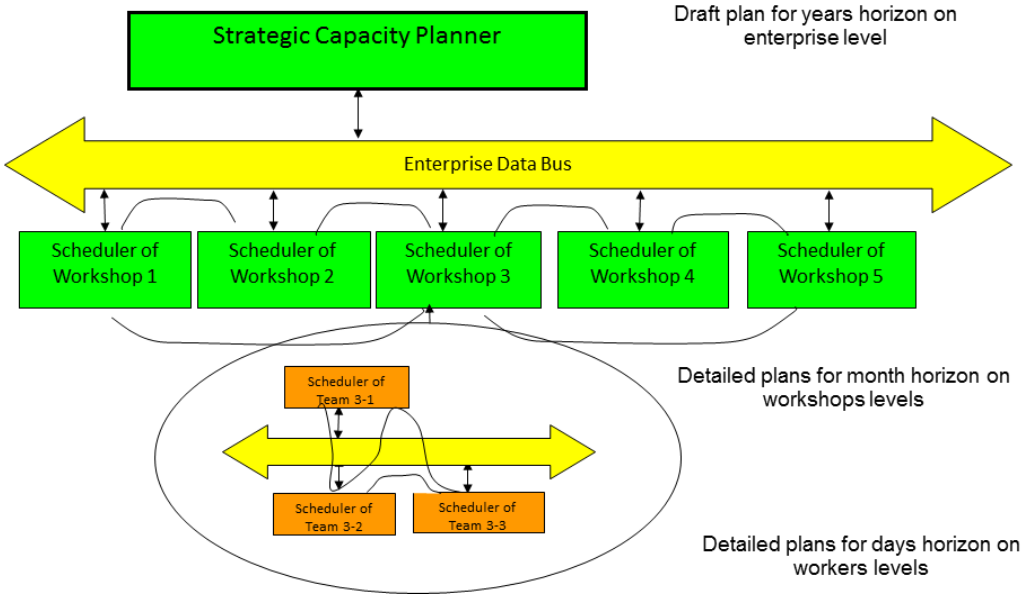


FIGURE 9: MULTI-LEVEL HOLONIC P2P NETWORK OF SCHEDULERS

Adaptive P2P network of schedulers will be implemented as SoA (Service-oriented Architecture) with ESB (Enterprise Service Bus) to provide open interfaces for future ad-hoc connections of new schedulers to the system bus.

Same approach can be applied for recursive nested multi-level architectures when one scheduler of workshop could be decomposed in adaptive p2p network of schedulers of teams in this workshop, etc. (example of P2P negotiation see Figure 10)

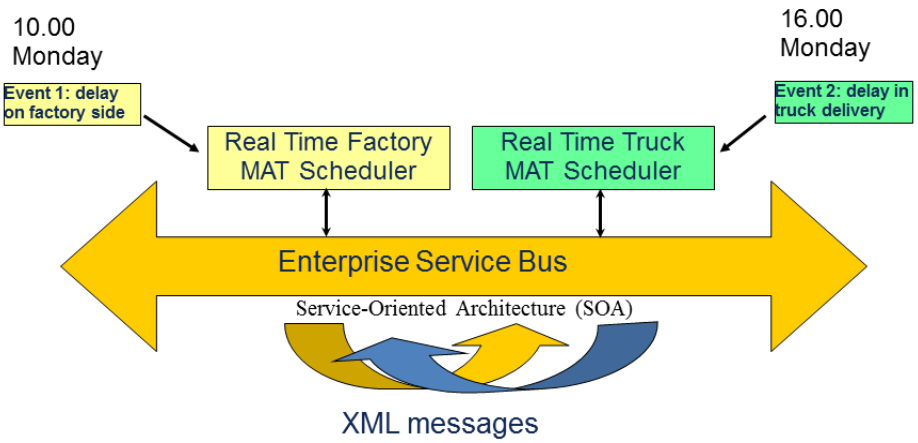


FIGURE 10: EXAMPLE OF NEGOTIATIONS IN ADAPTIVE P2P NETWORK OF SCHEDULERS

Such really holonic (“matroshka-style”) platform and architecture, where different schedulers can be placed on different servers, will be useful in providing very high openness, flexibility, scalability and performance, reliability of fully distributed intelligent systems for large-size manufacturers.

5. Knowledge Processing Multi-Agent Systems

As a result ARUM will develop and customize a comprehensive set of tools and methods providing the key ARUM functionality. The tools support the business strategies for real time scheduling, optimization and control of ramp-ups and production management at all management levels, mainly

strategic and tactical (operative). Design and development of the tools is driven by the requirements including user, functional and performance requirements.

The structure of tools for real time resource management is proposed on Figure 11.

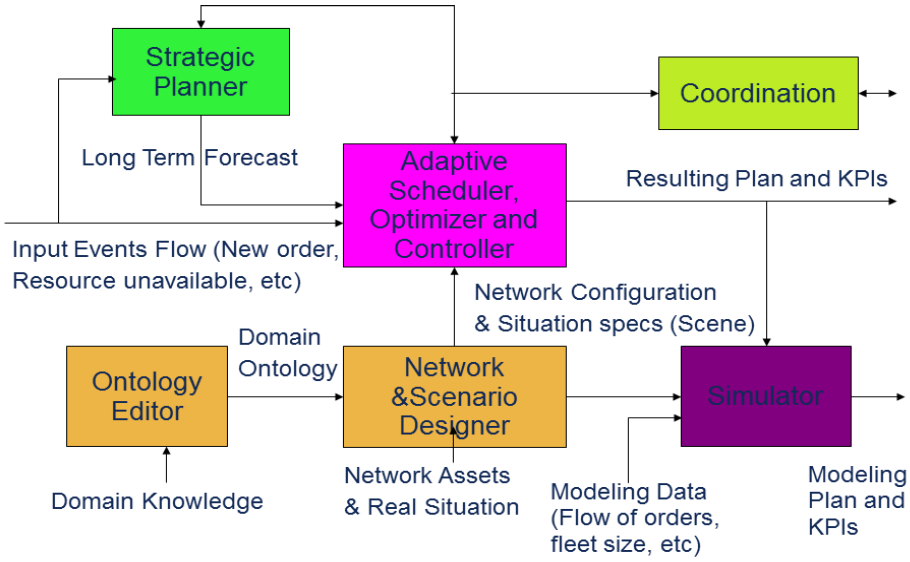


FIGURE 11: KNOWLEDGE-BASED MULTI-AGENT TOOLS FOR REAL TIME RESOURCE MANAGEMENT

Ontology is formal specification of problem domain of manufacturing, it contain concepts and relations around types of clients and orders, products and materials, equipment and workers, technological operations, documents, etc.

Ontology helps to specify problem situation (scene) as an instantiation of ontology classes for real life situation with concrete orders, equipment, names of workers, states of jobs, etc. Ontology management tools will be used for designing Network and Scenario Designer for constructing manufacturing networks (supply chains, factories, workshops, etc).

Strategic capacity planner will help to interactively forecast production plans for long period of time and then coordinate this plan with network of workshop schedulers. In this process workshop schedulers will have chance to coordinate their decisions using horizontal negotiations or in cases of conflicts and bottlenecks try vertical negotiations for changing constraints.

Adaptive resource allocation, scheduling and optimizing tools will cover full cycle of resource management (Figure 12): reacting on events, resource allocations, scheduling and optimization, coordinating plans with decision makers, monitors and controls plans automatically triggering re-scheduling in case of growing gap between plan and reality (as any autonomous organism).

The Simulator is able to run “what-if” scenarios when the user can model different real-life situations and to see the possible consequences as well as for stress testing to see the bottlenecks of the system what will address quality aspects including reliability, robustness and safety, etc.

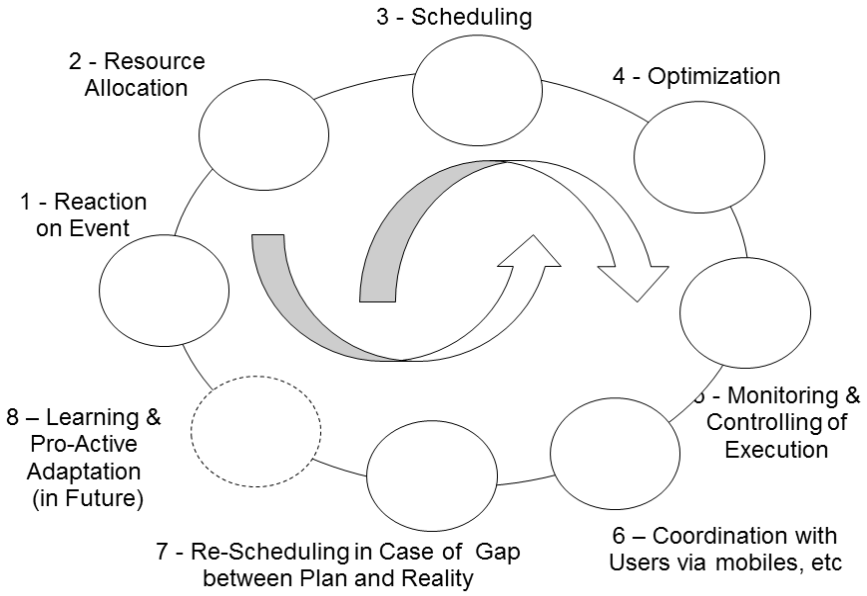


FIGURE 12: FULL CYCLE OF RESOURCE MANAGEMENT

This system can be applied on the level of whole factory or single workshop depending on size of manufacturer but if required – can be scaled up using holonic principles of superposition and recursion.

B 1.2 Progress beyond the state of the art

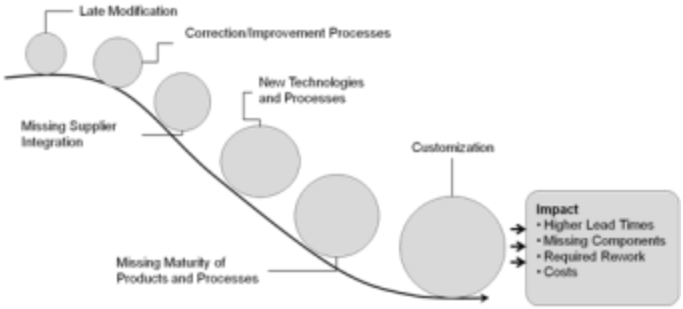
A summary of relevant projects is presented in Annex 2. The consortium will leverage its participation in these related projects to ensure an optimal integration level in ARUM.

Strategies for Ramp-up and small lot production

State of the Art

A ramp-up is the phase of transition between product development and the maximum capacity utilization. It is threatened by a variety of risks. These risks cause a significant reduction of the targeted production rate. Exploding costs are the result. Nowadays the growing competition and a shorter innovation cycle lead to a rising number of ramp-ups. Besides the complexity of high technology products itself future ramp-ups face further challenges.

Frequently occurring disruptions prove that product design, production lines, suppliers, IT or logistics are not ready. Late requests for change by customers are additional risks for the ramp-up. The challenge is to enhance the understanding of risks, faster respond to unexpected events, to enrich the base of information for decision making, to detect early warning and to accelerate learning.



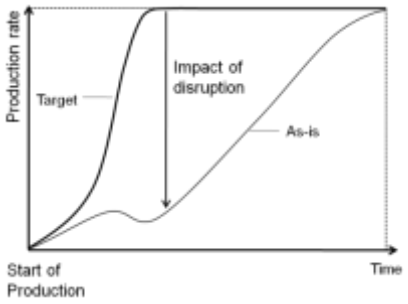


FIGURE 13: RAMP-UP CHALLENGES AND IMPACT ON A PRODUCTION SYSTEM FIGURE 14: IMPACT OF DISRUPTIONS ON RAMP-UP PRODUCTION NETWORK

Depending on the complexity of the product, product system and market conditions ramp-up faces different challenges. If these challenges are not handled correctly they turn into risks and finally disruptions which cause high impacts on costs and lead time.

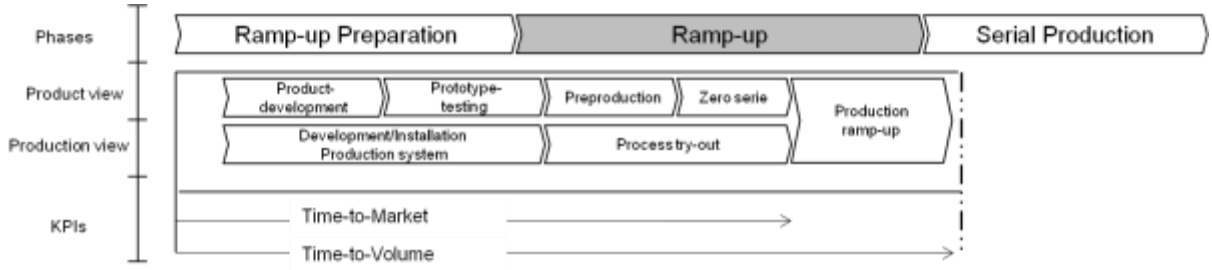


FIGURE 15: RAMP-UP WITHIN THE PRODUCT LIFE CYCLE (ACCORDING TO FITZEK, 2005)

In general, ramp-up marks the phase of transition between product development and the maximum capacity utilization. In order to concretize this broad definition we define the term as the period between the release of preproduction (or pilot production) and the achievement of stable production in terms of cost, quality, time and output targets. The ramp-up has to be considered from a product or production view in order to achieve the mentioned targets. Depending on the target and the challenges (see Figure 13) of the investigated production system an adequate business

strategy has to be identified. Before this step can be taken the ramp-up category (see Figure 16) of the use case needs to be identified.

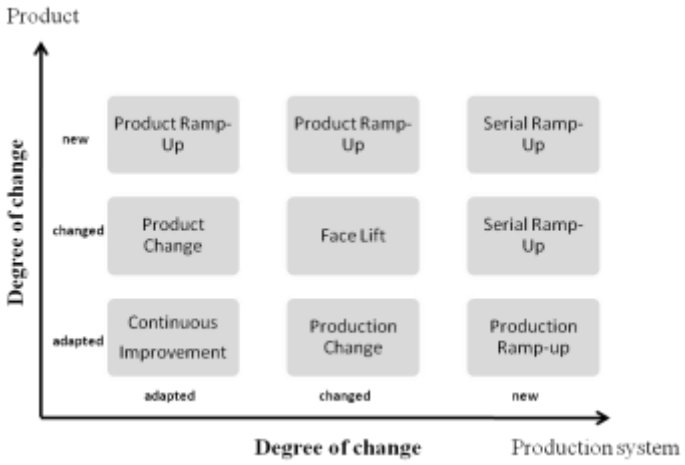


FIGURE 16: RAMP-UP CATEGORIES (ACCORDING TO F. DENZLER, 2007)

The selection of a business strategy is influenced by the ramp-up categories. Here ramp-up processes are classified according to the degree of novelty of product and processes compared to the predecessor.

Progress beyond

For the described challenges different approaches are possible. A gap analysis of the use cases is starting point in order to find an adequate approach. Also a combination of several approaches offers great benefit as praxis example proof. Thus, an example is shown for the ARUM project in Figure 18.

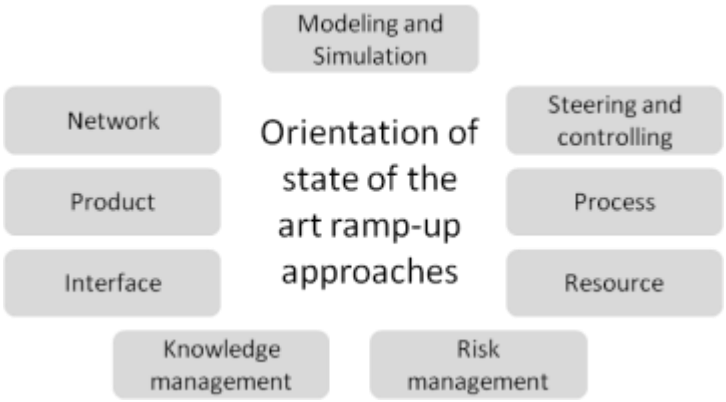


FIGURE 17: APPROACHES FOR RAMP-UP OPTIMIZATION

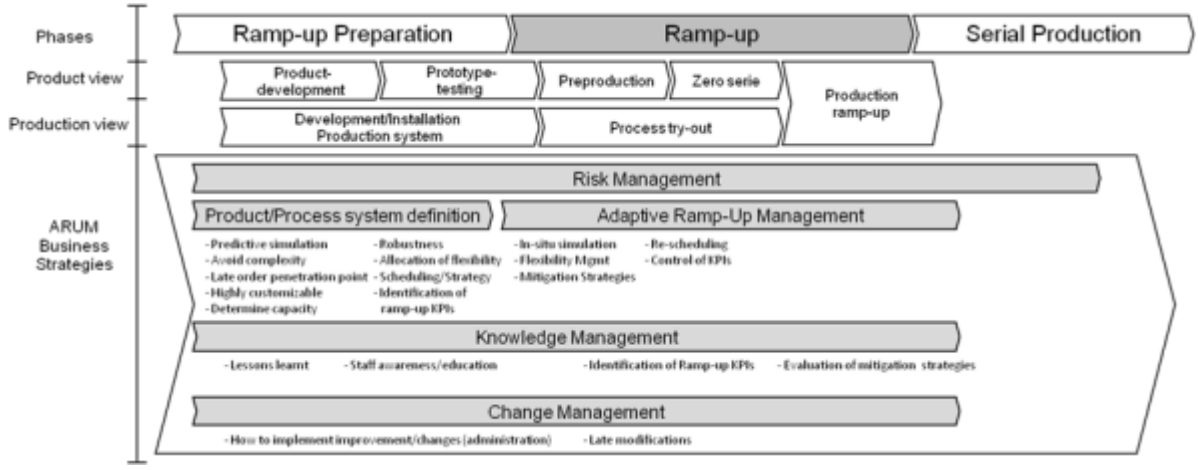


FIGURE 18: INTEGRATION OF SEVERAL RAMP-UP APPROACHES FOR ARUM

SOA-based Enterprise information System

State of the Art

Service oriented architecture (SOA) inherently incorporates Web principles through its layering on Internet protocols and publishing service descriptions as Web-addressable resources. Thereby SOA creates a very open and loosely coupled architecture. SOA also realizes information hiding principles as services are made available as independent services which can be accessed without knowledge of their underlying platform implementation. However, for using SOA as an enterprise information bus it needs to be based on additional principles which made the Web such a successful platform for the worldwide sharing of content. The major principles we consider as necessary for ARUM are:

- **Openness** implies that in principle any tool and legacy system can contribute as a provider or consumer of information, meaning that different roles will be made possible depending on the circumstances.
- **Interoperability** is needed and provided through the integration of different proprietary, legacy and existing solutions through open standards.
- **Decentralization changeability** and **dynamicity** implies that services, tools and legacy systems can appear and disappear in an uncontrolled fashion. Thus, the provisioning and modification of services and tools must be under the distributed control of peers rather than being controlled by a central authority. As a result, ARUM will follow decentralization paradigms, as it happens currently with the publishing procedures on the Internet.
- **Publication** as a means for n:m communication. The scalability of the Web as a communication platform is based on persistent publication versus targeted messaging. The first one adapts best to broad and potentially anonymous communication. Current (Web) service technology is still mostly geared towards targeted messaging.

A number of research and development projects have worked in the area, and a representative enumeration of these projects is covered in an Annex to this document, together with a detailed analysis of the way in which they serve the information needs of the enterprise.

In summary, however, these projects have failed to cover all principles listed above since they are based on either services or agents. Those based on conventional service technology find it difficult to

ensure the required degree of adaptation and openness for contemporary flexible and open environments, On the other hand, those based on holonic multi-agent systems are deemed to not deliver the necessary level of robustness and real-time responsiveness required by the target domain of manufacturing.

Progress beyond

To achieve progress on the areas outlined above, we integrate services and agents into an innovative three-layer service architecture linking legacy systems to agent-based control modules. In the middle we have a SOA-based enterprise information bus, managing the flow of information and coordination of different services and modules. In the top layer we have an innovative peer-to-peer infrastructure for distributed agent systems based on holonic principles. In the bottom layer we have a legacy systems integration interface, which links the service-based messaging and coordination bus to real-time sensors and legacy systems.

Together these three layers comprise the Intelligent Enterprise Service-based Platform (iESB) within the ARUM overall architecture. The iESB acts as an access layer to legacy systems and provides the communication and monitoring mechanisms for tools, services, and agent-based peer-to-peer networks to work on them.

The iESB becomes responsible for the transport of the individual messages from agent-based control tools to platform management modules and legacy systems. As the focal point, it enables and realizes the overall operational communication language and protocol of ARUM that enables it to achieve the promised interoperability to support dynamic ramp-ups. It takes the functionality offered by the individual systems and tools and orchestrates them into a coherent whole in an orderly and consistent fashion. We progress beyond state of the art in integrating agents and services in such a way as to enable the operation of the iESB with agent-based control tools and legacy systems in realistic scenarios.

Further details regarding the innovations at the agent layer are provided in the following section.

Knowledge processing Multi-agent-System

ARUM partners, especially CUAS, Certicon, CTU, IPB and SMRT have built its expertise in knowledge processing Multi-agent Systems on a proven collaboration at the forefront of multi-agent based research in an industrial context. In a couple of high level publications they have detailed analyzed the state-of-the-art , the previous and on-going R&D work in the field of Multi-agent systems for industrial automation.

The following publications will be used as starting point and state-of-the-art analysis for ARUM project:

- Vrba, P., Tichý, P., Mařík, V., Hall, K., Staron, R., Maturana, F., Kadera, P. Rockwell Automation's Holonic and Multi-agent Control Systems Compendium. IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, Vol. 41, Issue 1, 2011, pp. 14-30.
- Paulo Leitão, Pavel Vrba: Recent Developments and Future Trends of Industrial Agents. HoloMAS 2011: 15-28
- Paulo Leitão: Agent-based distributed manufacturing control: A state-of-the-art survey. Eng. Appl. of AI 22(7): 979-991 (2009)

The state-of-the art in industrial applications using Multi-agent Systems are well described by the following paper published by SMRT partner:

- Skobelev, P.: Multi-Agent Systems for Real Time Resource Allocation, Scheduling, Optimization and Controlling: Industrial Applications. In: Vladimír Maríik, Pavel Vrba, Paulo Leitão (Eds.): Holonic and Multi-Agent Systems for Manufacturing - 5th International Conference on Industrial Applications of Holonic and Multi-Agent Systems, HoloMAS 2011, Toulouse, France, August 29-31, 2011. Proceedings. Lecture Notes in Computer Science 6867 Springer 2011, page 1-14

State of the Art

Despite recent progress in operation research existing Enterprise Resource Planning (ERP) solution do not provide satisfactory solutions for resource allocation, scheduling and optimization in production sites of highly complex and variant products [1].

The ARUM solution needs to provide a high level of adaptability and responsiveness to a dynamic environment. A decision making processes between many users with conflicting interests needs to be coordinated. Traditional water-fall business processes need to be replaced by coordination mechanisms with back-and-forth negotiations. Costs for a highly customized product and individual production methods need to evaluated individually.

The growing challenge of “real time decision making” means that decisions must be taken “on the fly” and efficiency of resource utilization strongly depends on the moment of time. Any delay raises costs or cause follow-up risks, e.g. penalties by customers, lost sales, bankruptcy of suppliers or loosing reputation.

Classical batch optimizer ERP solutions by e.g. SAP, IBM, Oracle Corporation and many others usually apply different methods of batch constraint programming based on a combinatorial or stochastic approach. Unfortunately they are not applicable if the number of orders and resources is unknown in advance. Furthermore on-line rescheduling or communication with users is mostly very time-consuming. For example, scheduling 600 jobs in an existing scheduler can take up to 12 hours. On top results are not feasible and require manual re-work.

(Meta-) Heuristics To meet the requirements of real-world complexity and to speed up the process of finding satisfactory solutions simultaneously - compared to combinatorial approaches - heuristics are considered a promising approach. A heuristic makes use of experience-based techniques for problem solving and learning. Solutions of heurists not necessarily are proven correct but usually are intended to gain computational performance or simplicity.

As a result a remarkable number of new heuristic and meta-heuristic methods and tools have been developed in the last decades. Various local search methods, ant optimization, simulated annealing and tabu search method set representative examples [2].

Unfortunately many of these methods still do not fully match complexity and dynamics of real world use-cases nor do they meet the mentioned requirements like adaptability, responsiveness and decision support. An answer to these problems provide Multi Agent Systems.

Multi-Agent Systems for Solving Complex Problems Basic ideas of multi-agent technology (MAT) were formulated in the last decades of the 20th century starting at the edge of artificial intelligence, object-oriented and parallel programming, and telecommunications [10]. MAT is based on concept of software agent. This is an autonomous object which can react to external events, take intelligent decisions and communicate with other agents. The growing challenge of “real time decision making”

in this context means that the decision must be taken “on the fly” and efficiency of resource utilization strongly depends from moment of time – because any delay will cost money or bring many other problems: reduce service level for clients, brake delivery windows or driver regulations, generates new risks and penalties, etc.

The relevance for scientific and industrial approaches of Multi Agent Systems (MAS) is rapidly growing. This underlines the funding by the European Commission´s 6th Framework Program for agent based computing called AGENT Link. The commitment shows the value of the technology to solve very complex problems which are impossible to solve by classical mathematical methods, for example, in scheduling and optimization, pattern recognition, text understanding and clustering.

The latest approaches of MAT are based on bio-inspired ideas of self-organization and evolution. MAT in general supports the transition of complex systems from large centralized, monolithic and sequential programs with fixed hierarchical structure to distributed communities of small autonomous programs working asynchronously and in quasi-parallel. Furthermore they offer the opportunity to form networking structures and interact, compete and cooperate for complex problems solutions.

The value of such MAS in a modern complex and rapidly changing world is obvious. This is supported by impressive statistics of the scientific community. At the end of the 1980s MAS workshops gathered only 25-30 researchers. In the World Conference of Autonomous Agents and Multi-Agent Systems 2009 (AAMAS-2009) participated more than 600 delegates from 45 countries presenting results in the area of agent reasoning logic, knowledge presentation methods, platforms for multi-agent systems and application systems of social processes and modeling of robot control. Nowadays more than 25 commercial companies and 100 university projects in this area are worldwide well-known.

The number of commercial companies developing MAS is also rising. For instance Magenta Technology was founded in 2000 on the basis of the software engineering company “Knowledge Genesis” and gained valuable experiences in developing multi-agent systems for industrial applications in transportation. The company employees 150 highly qualified programmers today. Despite the required knowledge and the age of this young multi agent technology very successful industrial projects have been conducted already. Examples reach from network-centric logistics applications for military applications to the optimization of energy consumption for cottages.

Very successful results were achieved by applying the MAS approach to the largest fleet of corporate taxies in England (company Addison Lee). 13000 orders were negotiated between 800 cars equipped with mobile phones and GPS-navigation. A month after implementation the amount of fulfilled orders was increased by 7%. Now 97% of all taxi orders are planned automatically without dispatchers’ support. The percentage of orders not fulfilled on time dropped by 5%, idle running taxis even by 22.5%. This leads to an increasing profitability from each car of 5% and remarkable savings in fuel consumptions. From a customer perspective it needs to be highlighted that the ordering time was reduced significantly. Additionally the time for training of new operators dropped by 75% and the web-site works more efficiently now and can process 16% of orders more than before [14].

Equally proven successfully by the application of MAS were use-cases in tankers fleet management (Tankers International) and truck fleet management (GIST). In all use-cases the efficiency of resource allocation and the quality of client service was increased. Costs, risks and the dependence on human factors was reduced.

Holonic Multi-Agent Systems for Real Time Scheduling and Optimization To address new challenges of complex scheduling and optimization the paradigm of Multi-Agent Systems (MAS) and Holonic Manufacturing Systems (HMS) are becoming more and connected in designing complex, distributed and reconfigurable holonic knowledge-based multi-agent systems (HoloMAS). They are based on bio-inspired concepts of self-organization and evolution [15-16].

In general there are two main lines of R&D activities in these developments:

1. *Classical algorithms* implemented as a tools for agents OR use of agents for implementing classical algorithms to make them more adjustable. Research in this area deals with classical concepts, methods and tools of optimization to solve problems of batch schedulers.

2. *Bio-inspired approach***,** which requires development of new methods and tools for supporting fundamental mechanisms of self-organization and evolution similar to living organisms (colonies of ants, swarms of bees, etc).

The second approach is based on highly appreciated research of Artur Kestler on concept of holonic systems [15]. A first implementation of this concept in a PROSA system was done by Prof. H.Brussel, Prof. P.Valckenaers and others in the Katholieke Universiteit Leuven (Belgium) [16].

The holonic approach was developed and applied for production automation, air traffic control, unmanned vehicles and a number of other applications by Prof. Vladimir Marik, who is Science / Technology Coordinator and co-author of our project, Prof. Pavel Vrba, co-author of our project, and their teams in Technical University in Prague and Rockwell International (Czech Republic) [17]. The holonic approach for production control was further developed in ADACOR system in manufacturing [17] by Prof. Paulo Leitao (Polytechnic Institute of Braganca, Portugal) who is the one of world-leading R&D scientists in the area of bio-inspired multi-agent approach.

The scientific cooperation between scientists and engineers in related fields is supported by the International Conference on Holonic and Multi-Agent Systems (HoloMAS). Prof. Vladimir Marik, Prof. Paulo Leitao, and Dr. Pavel Vrba, all three being in this project's consortium, are well reputated Co-Chairs of the Program Committee of HoloMAS conference.

Industrial applications and European R&T projects Annex 6 summarizes the current world-known industrial application of agent technology in manufacturing – more details could be found in [21]. Currently also the number of projects focused on multi-agents systems is supported by EU Commission (Figure 19) [21].

Title	**Short description**
GRACE InteGration of pRocess and quAlity Control using multi-agEnt technology (www.grace-project.org/)	Use of multi-agent systems for integrating process and quality control, and consider self-adaptive procedures into control and diagnostic systems at local and global level handling variation in process set-point and variables and unplanned fluctuations of process/product parameters. The validation of the project results will consider a demonstrator in a washing machine production line.
IDEAS Instantly Deployable Evolvable Assembly Systems (www.ideas-project.eu/)	Development of demonstrators/technological solutions that proves that assembly equipment can be highly adaptable, applying the concepts of the Evolvable Assembly Systems (EAS) paradigm. Focus in the agent-based fault-tolerant control and reconfiguration aspects.
COSMOS COSt-driven adaptive factory based on MOdular Selfcontained factory units (EU ref. 246371)	Design, development and implementation of a control system for factory management with a flexible, modular and evolvable automation approach which will permit to increase the assembly factory productivity without losing flexibility. Focus on wind turbine assembly process.
COLLIS.EUS Soft Collaborative Intelligent	Development of collaborative information systems involving multiple interacting agents and soft-computing techniques for robotic and sensor

Title	Short description
Systems (FP7 ref. 255425)	systems. Covers a wide range of applications such as manufacturing, scheduling, control, diagnosis, logistics, energy and road traffic management.
CONET Cooperative Objects Network of Excellence (www.cooperating-objects.eu/)	Development of a community in the area of Cooperating Objects capable of conducting the needed research to achieve the vision of combining embedded systems for robotics and control, pervasive computing and wireless sensor networks.
AESOP (ArchitecturE for Service-Oriented Process - Monitoring and Control; www.aesop-mc.eu)	Service-oriented computing principles for monitoring and control of process control applications.
Self-Learning (www.selflearning.eu)	Highly reliable and secure service-based self-learning solutions aiming the integration of control and maintenance of production systems
MEDEIA (Model-Driven Embedded Systems Design Environment for the Industrial Automation Sector; www.medeia.eu)	IEC 61499 reference models and 4DIAC as potential implementation platform to achieve the development of embedded control systems within the European industrial automation sector.

FIGURE 19: SURVEY ON EUROPEAN R&D PROJECTS ADDRESSING INDUSTRIAL AGENT TECHNOLOGY

Progress beyond

ARUM modern vision of knowledge-based multi-agent systems is presented in Figure 20.

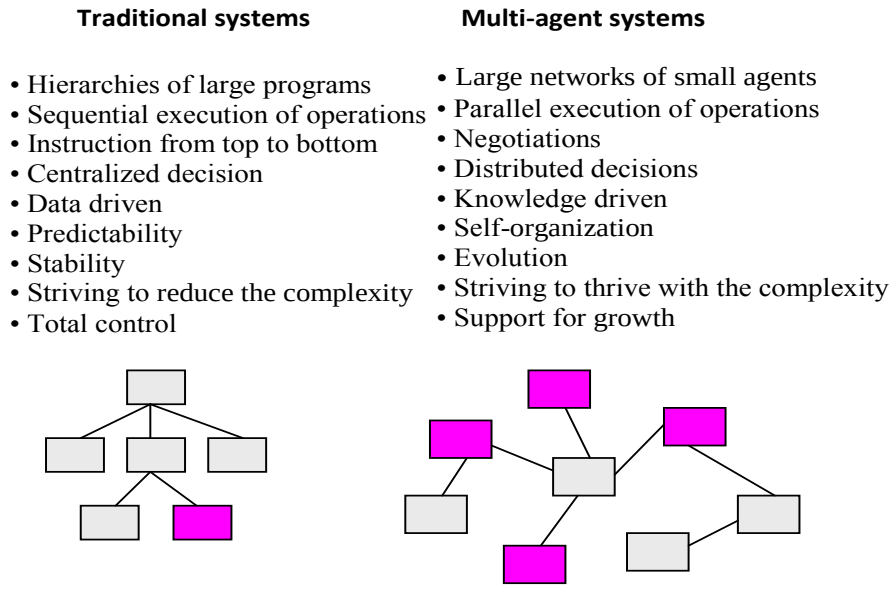


FIGURE 20: COMPARE TRADITIONAL AND MULTI-AGENT SYSTEMS

ARUM designed multi-agent systems will use the concept of co-programs which are working as state machines under the control of dispatcher, which executes agents in an asyncronic and quasi-parallel way within one thread of execution. This approach significantly differs from platforms like JADE, Cougaar, Agent Builder, JACK and others and provides quasi-parallel work of hundreds and thousands of agents in one thread.

In contrast with object-oriented programming approaches the agent cannot be invoked as a state-less object and implemented as a method. But it can be asked to implement the task – for this reason he needs to communicate with other agents and make re-commitments. The decision of any complex task in this system is made evolutionarily by interaction of dozens, hundreds or even thousands of

agents which steadily compete and cooperate with each other, create and break solution until the required quality level of problem solution is reached.

The holonic approach allows solving complex problems in a real time in the sphere of resource planning and optimization, patterns recognition, text understanding and others. In ARUM vision it gives multi-agent technology the generic solid basis of bio-inspired classes of agents and advanced framework for designing complex "systems of systems" as a nested swarms of agents which help to balance interests of selfish agents and groups of agents and provide high performance and scalability of multi-agent systems.

In designing adaptive scheduling systems ARUM suggest to follow Ilya Prigogin's theory of complexity and consider the scheduling itself as a self-organized dissipative structure which has "unstable equilibriums" (or "stable non-equilibriums'). This approach helps to understand, analyze and predict complex behavior of this new generation of multi-agent scheduling systems. It offers solutions to control behavior of such systems, to provide quality and efficiency of scheduling.

To summarize the results we can specify key value for manufacturing in Figure 21.

Traditional approach	**Multi-agent approach**	**Value / Importance**
Tend to decrease complexity of real world	Tend to increase complexity for real life manufacturing	The opportunity to get high quality and efficient solutions
Batch planning mode	Event-driven in real-time	Time importance – decisions need to be taken asap
Top-down instructions, important details are lost	Individual approach and bottom-up self-organization	High productivity and staff satisfaction
Combinatorial optimization	Balance of interests based on trade-offs	Better quality and efficiency of scheduling and optimization
Support of waterfall business processes	Support of networking	Coordinated decision-making

FIGURE 21: VALUE FOR MANUFACTURING

The conclusion is that non one of these projects above is dedicated to provide multi-level holonic knowledge-based multi-agent real time scheduling and optimization solution for large-scale manufacturers.

B 1.3 S/T Methodology and associated work plan

B 1.3.1 Overall strategy and general description

The main goal of ARUM is to develop novel strategies, systems and tools and to integrate them into a scalable architecture supporting the integrated control and dynamic optimization of factory assets for production ramp-up and small batch production series of complex and highly customized products. The ARUM solution will target on the vertical integration of information across all production levels as well as the horizontal integration of information along the engineering, production system planning and manufacturing processes.

To head the evolving complexity of those production ramp-ups and small batch production series and the wide spectrum of different industrial production systems and end users the ARUM project aims to develop an adaptable, modular and scalable ICT solution based on an open and scalable architecture for automated control and optimization.

The work plan for that approach starts with capturing and analysis of the end-users requirements and the definition of use cases for the ARUM project. Based on that, the specification and adaptation/development of technical bricks required for the ARUM solution and the overall architecture will be developed. Finally the end-users will be heavily involved again in technical trails, assessment and benchmarking activities for validation the ARUM solution against today's automation control and optimization solutions. Final step is the demonstration, dissemination and exploitation of ARUM results to the R&T and European end-user community.

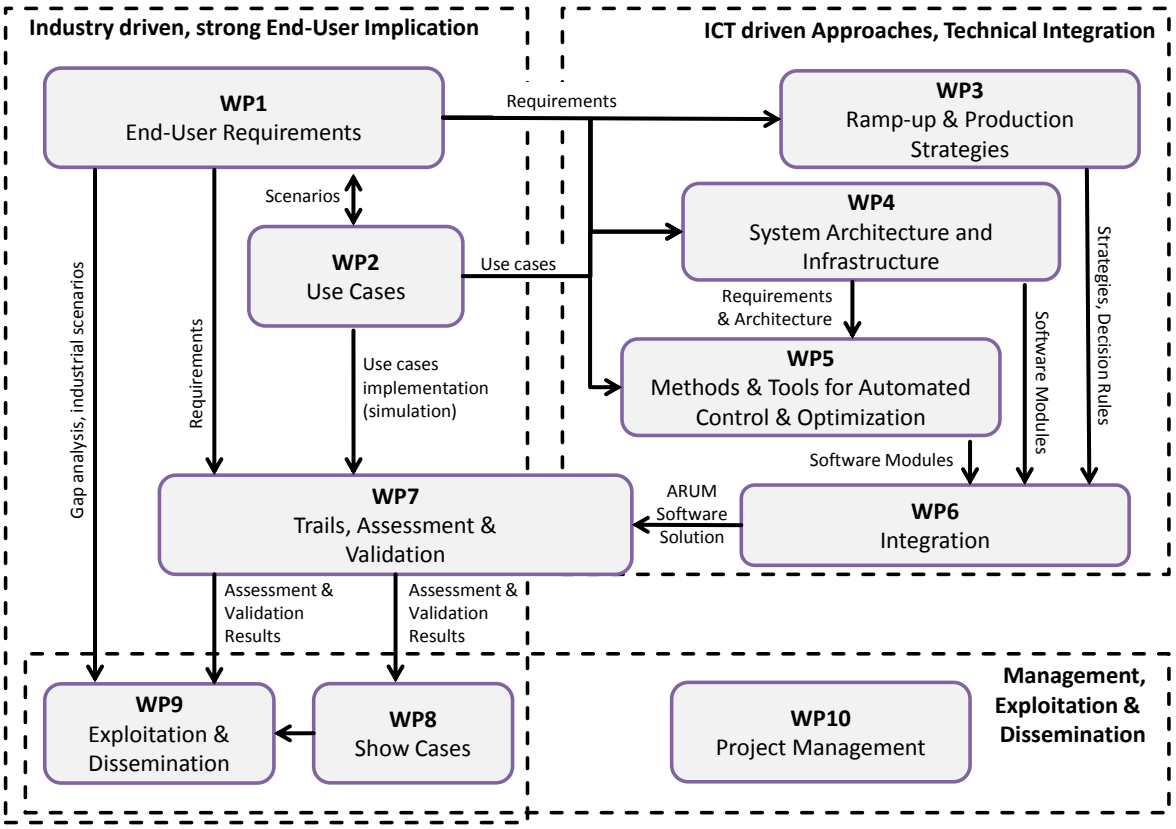


FIGURE 22: PRESENTATION OF THE WORK PLAN

The following top level work plan reflects the intention of the project (compare Figure 22):

WP1 End-User Requirements
WP2 Use Cases
WP3 Ramp-up & Production Strategies
WP4 System Architecture and Infrastructure
WP5 Methods and Tools for Automated Control & Optimization
WP6 Integration
WP7 Trails, Assessment & Validation
WP8 Show cases

Within **WP1** the actual ramp-up and small lot production practices will be compared to best practice industrial production systems and weaknesses, and resulting end-user needs will be analysed. Based on that comparison and those user needs, a gap analysis will result in to the end-user requirements for the ARUM solution. WP1 will be performed by industry, assisted by the industrial companies from EAB and other stakeholders. In **WP2** the use cases based ion industrial scenarios will be defined und implemented for validation and demonstration the ARUM solution in WP7 and WP8.

Following the end-user driven approach those requirements will be translated in **WP3, WP4 and WP5** into the ARUM ramp-up and production strategies, the system architecture and ICT systems and tools. All three WP will than develop and provide the technical bricks as needed for the ARUM solution to be integrated in **WP6**.

Again the end users will be heavily involved in supporting the performance validation of ARUM solution by trails using the ARUM testbed linked to the real industrial environment, economic and operational benefit assessment and benchmarking against today's existing ICT solutions in **WP7**.

Finally the ARUM research findings will be disseminated and exploited across the scientific and industrial community by performing a set of show cases of the ARUM solution for the end-user based on defined use cases in **WP8** and additional regular exploitation and dissemination activities as well as standardization proposals for ARUM results to be performed in **WP9**. Figure 23 shows the detailed work breakdown inclusive single tasks of the WP.

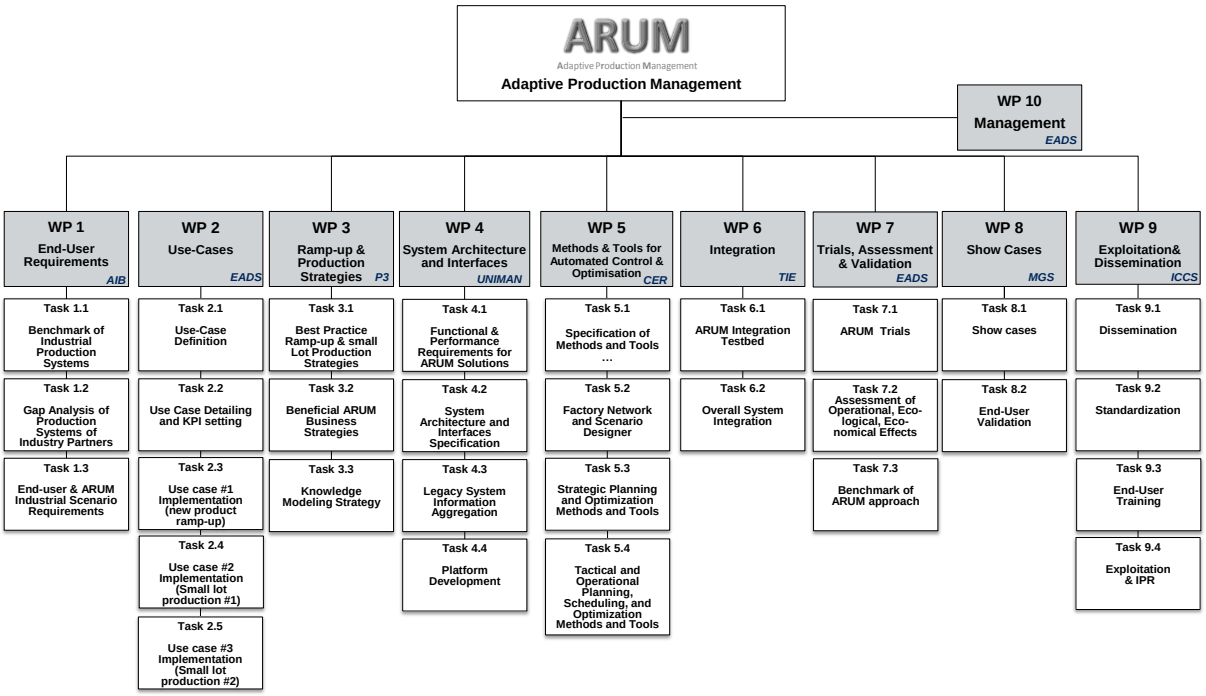


FIGURE 23: WORK BREAKDOWN STRUCTURE (WBS)

The ARUM approach addresses the four pillars of business strategy development, development of ICT systems for integrated control and dynamic optimization, the development of tools to support for integrated control and dynamic optimization and the end-to-end integration with legacy systems and across production levels are well reflected in work plan (major project milestones), by deliverables and resource allocation (see Table 1).

Objective	linked WPs/ Tasks	Major Deliverables	linked Milestones	Ressources allocated
Development of risk mitigation & management strategies	WP3	D3.2-1,2,3 Beneficial ARUM Business Strategies (1st, 2nd, final release)	M9, M10, M11	75 MM
Development of ICT systems for integrated control & dynamic optimization	WP4	D4.1-1 System Architecture and Platform Specifications	M7	38 MM
		D4.3-1,2,3 Legacy System Integration Specifications and Components (1st, 2nd, final release) D4.4-1 iESB platform and guides (user and programmer)	M9, M10, M11	199 MM
Development of tools supporting integrated control & dynamic optimization	WP5	D5.1-1 Methods and tools specifications	M7	42 MM
		D5.2-1,2,3 Factory Network and Scenario Designer (1st, 2nd, final release) D5.3-1,2,3 Strategic Planning and	M9, M10, M11	243 MM
End-to-end integration with legacy systems and across production levels	MP6	D6.2-1 Overall System Integration & Verification	M12	82 MM

TABLE 1: MAJOR DELIVERABLES, MILESTONES AND RESSOURCES LINKED TO ARUM OBJECTIVES

The five underlying challenges ARUM project is based on are reflected in project structure as shown in following Table 2.

Challenges	Major WP / Task involved
End-user requirements elicitation	Task 1.3: requirements management Tasks 7.2, 7.3: measurement by end-user requirements fulfilment
Validation within real industrial environment	Tasks 2.1-2.5: use case definition and implementation Task 6.1, 6.1: ARUM testbed linked to real industrial environment Task 7.3 : benchmarking against real, state of play solutions of industrial partners
Integration across all hierarchies and along all manufacturing processes	Task 1.3: to define the end-user requirements on integration Tasks 2.1-2.5: use cases for horizontal and vertical integration Tasks 4.3-4.4: to develop solutions for legacy system integration / iESB based architecture supporting the integration WP7 to validate the integration against the end-user requirements
SOA-based EIB	- ARUM central technology approach - WP4 to implement the technology
Knowledge processing	- ARUM central technology approach (MAS) - WP4 & WP5 to implement the technology

TABLE 2: ARUM CHALLENGES AND PROJECT STRUCTURE

B 1.3.2 Timing of work packages and their components

The project duration will be 37 month. A detailed planning has been established (up to task level) to ensure that the project could be adequately monitored by the project management structure and the EC.

Work Package			Year 1													Year 2												Year 3											
No	Name	Lead	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
WP 1	End-User Requirements	**AIB**																																					
Task 1.1	Benchmark of Industrial Production Systems	P3																																					
Task 1.2	Gap analysis of Production systems of Industry Partners	AIB																																					
Task 1.3	End-user & ARUM Industrial Scenario Requirements	EADS																																					
WP 2	Use-Cases	**EADS**																																					
Task 2.1	Use-Case Definition	EADS																																					
Task 2.2	Use-case planning and KPI setting	P3																																					
Task 2.3	Use-case#1 implementation (ramp-up production)	AIB																																					
Task 2.4	Use-case#2 implementation (small lot production #1)	MGS																																					
Task 2.5	Use-case#3 implementation (small lot production #2)	EADS																																					
WP 3	Ramp-up & Production Strategies	**P3**																																					
Task 3.1	Best Practice Ramp-up & small Batch Production Strategies	P3																																					
Task 3.2	Beneficial ARUM Business Strategies	P3																																					
Task 3.3	Knowledge modeling strategy	CUAS																																					
WP 4	System Architecture and Interfaces	**UNIMAN**																																					
Task 4.1	Functional & Performance Requirements for ARUM Solutions	CER																																					
Task 4.2	System Architecture and Interfaces Specification	UNIMAN																																					
Task 4.3	Legacy System Information Aggregation	TIE																																					
Task 4.4	Platform Development	CER																																					
WP 5	Methods & Tools for Automated Control & Optimization	**CER**																																					
Task 5.1	Methods & Tools Specification	CER																																					
Task 5.2	Factory Network and Scenario Designer	CUAS																																					
Task 5.3	Strategic Planning and Optimization Methods and Tools	CER																																					
Task 5.4	Tactical and Operational Planning, Scheduling, and Optimization Methods	SMRT																																					
WP 6	Integration	**TIE**																																					
Task 6.1	ARUM integration testbed	TIE																																					
Task 6.2	Overall system integration	TIE																																					
WP 7	Trials, Assessment & Validation	**EADS**																																					
Task 7.1	ARUM Trials	EADS																																					
Task 7.2	Assessment of Operational, Ecological, Economical-Effects	P3																																					
Task 7.3	Benchmark of ARUM approach	UNIHA																																					
WP 8	Show cases	**MGS**																																					
Task 8.1	Show cases	MGS																																					
Task 8.2	End-user Validation	EADS																																					
WP 9	Exploitation & Dissemination	**ICCS**																																					
Task 9.1	Dissemination	TIE																																					
Task 9.2	Standardization	ICCS																																					
Task 9.3	End-User Training	AIB																																					
Task 9.4	Exploitation & IPR	EADS																																					
WP 10	Management	**EADS**																																					

FIGURE 24: ARUM GANTT CHART

The Workplan tables of Part A form an essential part of the Description of work and are closely linked to this section. You do not have to repeat the workplan tables in the narrative part. Make sure you are using references to the work packages, deliverables and milestones, etc. in a consistent manner.

WT1 List of work packages
WT2 List of deliverables
WT3 Work package descriptions
WT4 List of milestones
WT5 Tentative schedule of project reviews
WT6 Project effort by beneficiaries and work package
WT7 Project effort by activity type per beneficiary
WT8 Project efforts and costs

Project flow

The Pert Diagram below (Figure 25) presents the global project work flow and also the links and interdependencies between WP and main tasks.

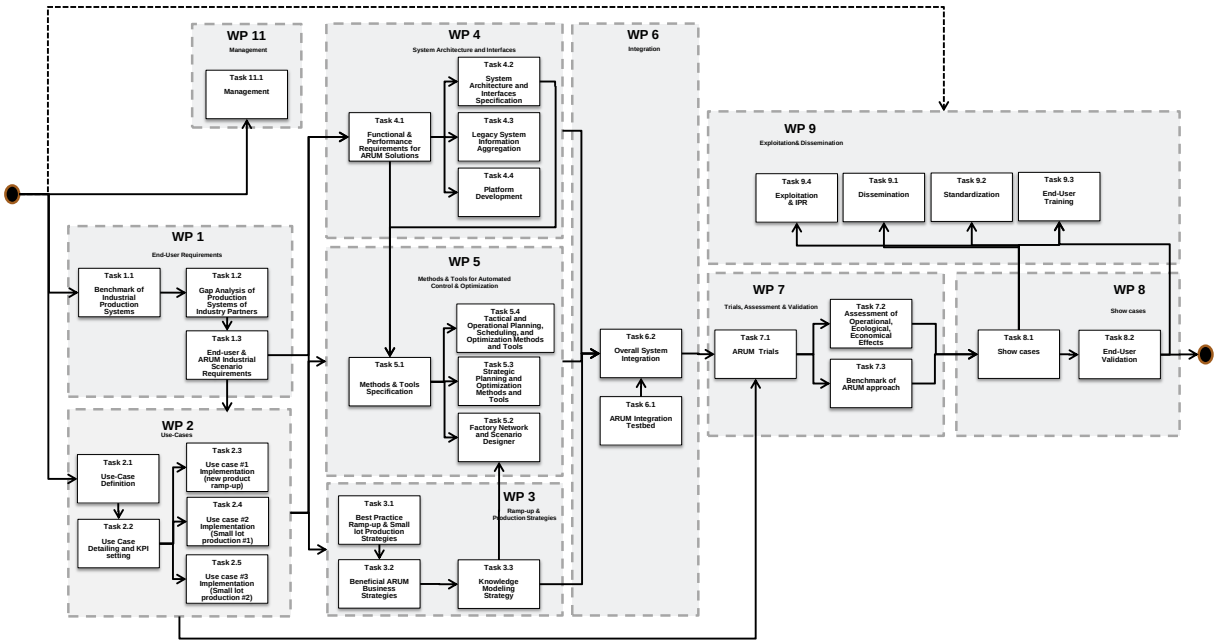


FIGURE 25: PERT CHART - PROJECT FLOW AND MAIN LINKS BETWEEN WP

ARUM will start with a benchmark of industrial production systems and a Gap analysis of production systems of the ARUM industrial partners (Airbus, MGS & Flensburger Shipyard) Based on those gaps the ARUM End-user and scenario requirements will be derived. In parallel and linked to the end-user requirements the ARUM Use-Case will be defined and modeled. Out of these end-user expectations the technology development will be started in WP3, WP4 and WP5. Promising strategies for risk reduction, mitigation and management will be analyzed and adapted in WP 3 into decision rules and planning and control knowledge representations. The architecture and the methods & tools for predictive simulation and real-time control and optimization will be specified and developed in WP 4 & WP 5. In WP 6 the ARUM test bed will be implemented and used for integration of all technical elements from WP3, WP4 and WP5 into the overall ARUM solution. The validation & assessment of

the ARUM business strategies will be performed on the basis of the predefined use-cases in WP 7. In WP8 the ARUM approach will be disseminated to end-users by performing a set of show cases.

WP 9 (Exploitation & Dissemination) and WP 11 Project Management are transversal by nature.

Iterative development and requirements management

The ARUM project will benefit from an iterative approach to accommodate for a step-wise integration and validation including the re-iteration and verification of the requirement settings along the project (see Figure 26). For that reason the work plan includes three milestones relevant for WP3, WP4 and WP5 subsystem development:

- 1st prototype release /business strategy definition at month 19
- 2nd prototype release / business strategy definition at month 25
- Final prototype / business strategy at month 27

The requirements management and verification along the whole project lifetime will be managed by task 1.3 and will support the iterative development and integration and final validation be technical means (requirements management toolset).

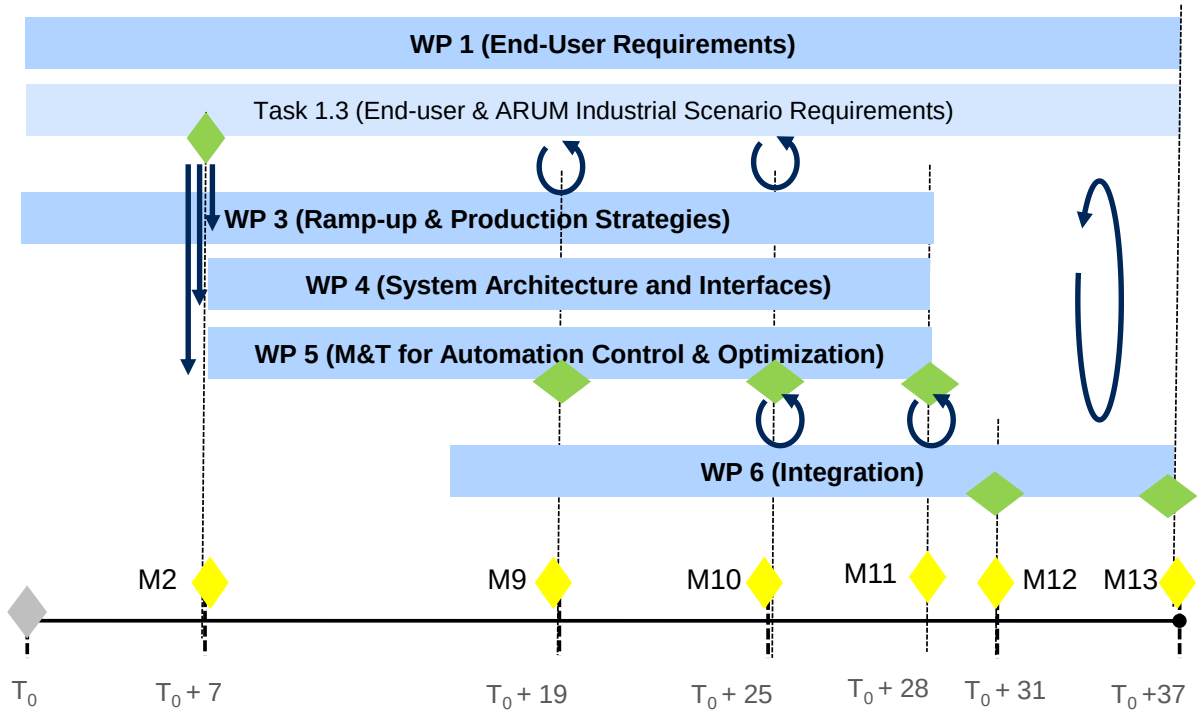


FIGURE 26: ITERATIVE DEVELOPMENT AND REQUIREMENTS MANAGEMENT

The following Table 3 shows the major milestones and deliverables supporting the requirements management along the project, the iterative development approach and interactions between WP1, WP3, WP4, WP5, WP6 and WP7.

Milestones	Time	Major Deliverables	Involved WP
M2: End-user requirements defined	t+7	D1.3-2 End-user & ARUM industrial scenario Requirements	WP1
M7: specification phase completed	t+15	D2.2-1 Use-Case Detailing and KPI setting D4.1-1 System Architecture and Platform Specifications D5.1-1 Methods and tools specifications	WP3, WP4,WP5 detailed requirements in WP1 managed
M9: 1st Software release (tools, architecture); business strategies definition 1st draft	t+19	D3.2-1 Beneficial ARUM Business Strategies (1st release) D4.2-1 First prototype of iESB components and P2P agents layer D4.3-1 Legacy System Integration Specifications and Components (1st release) D5.2-1 Factory Network and Scenario Designer (1st release) D5.3-1 Strategic Planning and Optimization Tool (1st release) D5.4-1 Tactical and Operational Planning, Scheduling and Optimization Tool (1st release)	WP3, WP4, WP5 requirements refinement and local validation ongoing supported by WP1
M10: 2nd Software release (tools, architecture), business strategies 2nd draft	t+25	D3.2-2 Beneficial ARUM Business Strategies (2nd release) D4.3-2 Legacy System Integration Specifications and Components (2nd release) D5.2-2 Factory Network and Scenario Designer (2nd release) D5.3-2 Strategic Planning and Optimization Tool (2nd release) D5.4-2 Tactical and Operational Planning, Scheduling and Optimization Tool (2nd release)	WP3, WP4, WP5 first integration tests in WP6 requirements refinement and local validation ongoing supported by WP1
M11: Software final releases, business strategies B13finalized and reviewed	t+28	D3.2-3 Beneficial ARUM Business Strategies (final release) D4.3-3 Legacy System Integration Specifications and Components (final release) D4.4-1 iESB platform and guides (user and programmer) D5.2-3 Factory Network and Scenario Designer (final release) D5.3-3 Strategic Planning and Optimization Tool (final release) D5.4-3 Tactical and Operational Planning, Scheduling and Optimization Tool (final release)	WP3, WP4, WP5 integration in WP6 runs local requirements validation supported by WP1
M12: ARUM solution integrated	t+31	D6.2-1 Overall System Integration & Verification	WP6 requirements refinement and local validation ongoing supported by WP1
M13: ARUM solution validated	t+37	D1.3-3 ARUM Requirements Validation Report D7.2-1 Assessment of Operational, Ecological, Economical Effects D7.3-1 Benchmark of ARUM approach D8.2-1 End-User Validation	WP7, WP8, WP1

TABLE 3: MAJOR MILESTONES AND DELIVERALES FOR ITERATIVE DEVELOPMENT AND REQUIREMENTS MANAGEMENT

Use cases and validation and demonstration

The use cases defined in WP2 are the baseline for the validation and demonstration of the ARUM solution developed in WP3, WP4 and WP5 and integrated in WP6. The interaction of use case definition in WP2 and validation and demonstration of ARUM results in WP7 and further dissemination by a set of show cases in WP8 are shown in following figures (Figure 27, Figure 28).

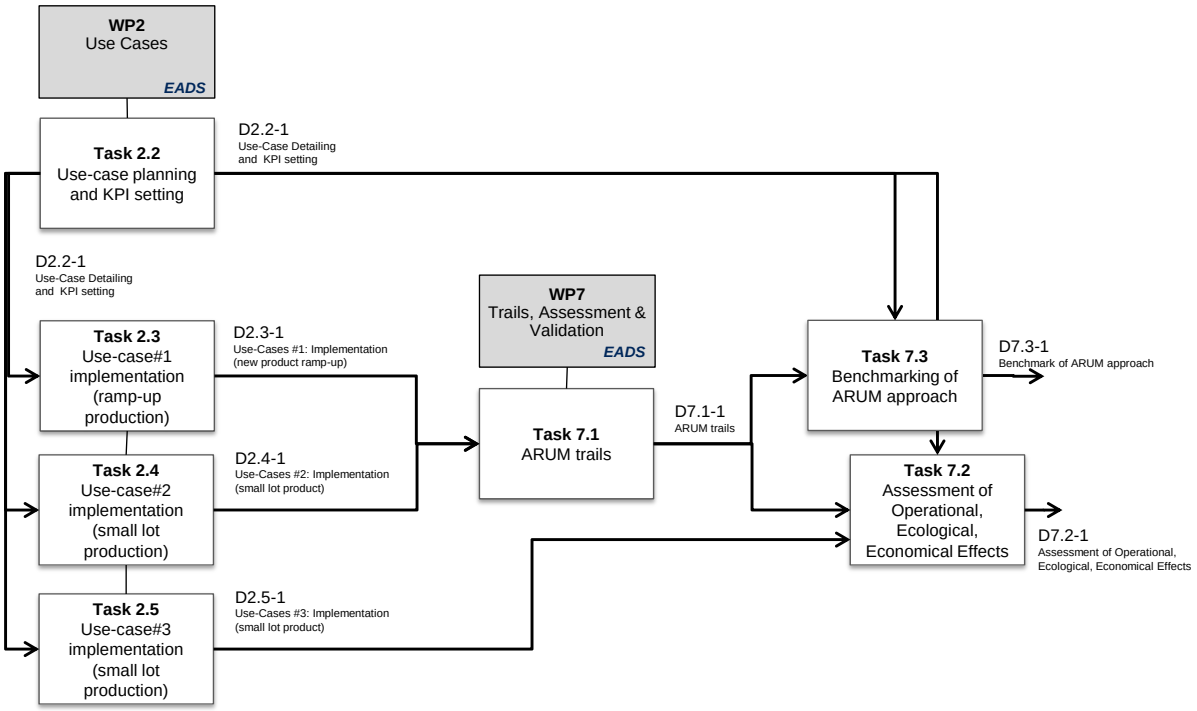


FIGURE 27: USE CASE – VALIDATION INTERACTION (WP2 – WP7)

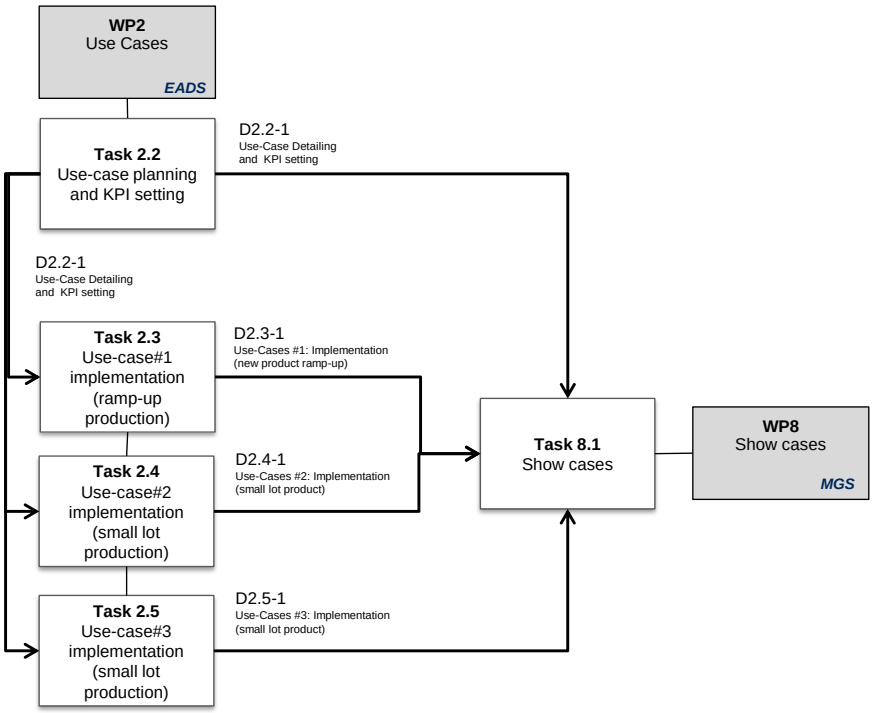


FIGURE 28: USE CASE – SHOW CASES INTERACTION (WP2 – WP8)

Risks and contingency plans

Table 4 presents the identified risks, their level and the proposed mitigation plan for project level and specific WP and tasks. These risks as well as any other identified during the project will be monitored by the consortium.

WP / Task	Identified risks	Level	Risk mitigation
Project level	Weak involvement of stakeholders/ End-user/ External Advisory Board (EAB)	Low	Pre-existing contacts with several industrial partners
Project level	Management of the diversity underlying administrative cultures	Low	Existing expertise in multi-national projects
Project level	Project roles (management, e.g. PC, WPM) needs to be changed during the project.	Low	Another highly skilled person will be chosen. In case of PC: One of the partner representatives in the PMB will temporarily serve as coordinator
Project level	Changes of legal situation, withdrawal of a partner, unforeseen disclosure of information	Low	Grant agreement, consortium agreement and Management Plan, Non-Disclosure Agreement clause.
Project level	Not following the plan and not meeting the deadlines, (e.g., key milestones or critical deliverables are delayed)	Low	The risk is reduced by the expertise and commitment of the partners (technical skills and management experience) that will enable forecasting of departures from plans. The deliverables/ milestones lying on the critical path of the project activities will be constantly monitored by the management team so that delays are avoided. The project coordinator will keep on top of the situation with regular status meetings with the partners, including regular updates from the WP leaders in between the project consortium meetings. The coordination team and technical committee will re-prioritise project goals where necessary.
Project level	Loss of focus on vision, objectives and milestones	Low	Already minimised by the close efforts and focus put in by all partners in the proposal stage. Measures to be taken include regular work progress assessment by the Technical Committee and plenary board. In cases where the project might seem to go off track, the plenary board will take immediate corrective action, which could include shifting competencies, changing partner budgets, changing leadership roles and so on.
Project level	Slow technology adoption and lack of end user involvement	Low	The project is both technology-oriented and user-driven. Therefore, the project team will consider the feedback from the end users at all project stages on any new technologies developed.
WP 1, WP 2	End users from Airbus, MGS and FSG (shipyard) do not have	Low	Airbus and EADS (close linked research organization with direct access to relevant

WP / Task	Identified risks	Level	Risk mitigation
	sufficient time needed for the requirements and use case definition. Detail level of requirements and use case definition too low for ARUM		information) is involved in ARUM with sufficient budget in WP1 and WP2. MGS is partner in ARUM and has sufficient budget allocation for WP1 and WP2. FGS has already confirmed the participation in EAG (see letter of intent) and was involved in proposal preparation.
WP 1, WP 2, WP 7	The requirements cannot be satisfied due to technological limits, unclear requirement and use case descriptions	Medium	Strong interaction between end-users and technology providers in requirements definition in task 1.3 and use case definition in task 2.1 Use of formal modelling of requirements in task 1.3 and use cases in task 2.1 and sufficient requirements management in task 1.3
WP 4	The developed platform does not meet the relevant conditions outlined by the use cases	Low	We will set up an iterative design and development process that will enable us to regularly monitor and identify conditions set and any changes that may negatively affect the development process.
WP 4, WP 5, WP 6	Unforeseen problems regarding the interaction between the various components and/or software modules	High	a) Change interface specifications and/or fix problems in the software modules causing the problems. b) Pre-integration test in WP 4 & 5 c) Iterative development approaches (e.g. SCRUM) allow the integration of partial systems at an early stage in WP6
WP 4, WP 5, WP 6	Software is not available in time for validation and assessment tasks in WP 7.	Medium	Iterative development approaches (e.g. SCRUM) in WP4 and WP5 ensure that partial systems are available at an early stage. In WP6 preliminary integration steps will provide software versions for selected trails and validation tasks. Test plan defined by Task 7.1 will support stepwise validation.
WP 6	Difficulty to integrate software modules from WP 4 and 5 into ARUM overall system	Low	Expertise of partners, involvement of all major development partners from WP4&5 in Task 4.1 and Task 4.2
WP 8	Schedule problems, problems during implementation of the show cases	Medium	Responsibility for the work package clearly defined, sufficient time, budget and resources allocation for WP8 is foreseen.
WP 9 WP 8 Project Level	Negative feedback during dissemination activities. Schedule problems, problems during implementation of the show cases	Low - Medium	The dissemination activities will start early enough, in order to get feedback from the potential market and industry, thus allow for accordingly tuning the project. Responsibility for the work package clearly defined, sufficient time, budget and resources allocation for WP8 is foreseen.
WP 9 Project	Failure to comply with international standards.	Low	ARUM consortium has been carefully assembled in order to accumulate strong

WP / Task	Identified risks	Level	Risk mitigation
Level			know-how from all the different fields tackled by the project; moreover, ARUM benefits from the participation of several organisations that are active within standardisation bodies.
WP 9 Project Level	Negative feedback during standardisation activities.	Low	ARUM partners are overall quite experienced in standardisation, some of them holding important roles in standardisation boards. Thus, ARUM development will be in line with international standards since the beginning, paving the way for the emergence of new ones. In the case where acceptability is poor, ARUM will adapt with corrective design choices.
WP 9 Project Level	Internal disagreements regarding intellectual property rights.	Low	The bottom-line rules for the management of Intellectual Property Rights within ARUM will be the Consortium Agreement that will contain the corresponding appropriate clauses, in line with Annex II of the FP7 Model Grant Agreement. Moreover, in the context of Task 9.4, ARUM partners will consider and devise concrete IPR provisions at every major milestone of knowledge production and release, as well as software development, including design and development cycle start and end. When necessary, the emerging issues will be addressed at the management level, also making use of the services of the European Commission's IPR Helpdesk.

TABLE 4: RISKS AND MITIGATION

B2. Implementation

B 2.1 Management structure and procedures

EADS IW (EADS) as part of EADS Deutschland GmbH will act as the Coordinator of the ARUM Project. EADS has a proven track record in the project management of complex, multiple organisation activities at the RDT level in the EU context (EC or EDA). EADS possesses ISO9001-2000 certification for leading and achieving researches and the project will be managed to that standard.

As management is a key factor for the success of such integration projects (IP), EADS proposes an organisation and procedures that have already proven their efficiency in previous and current EC research activities.

A specific project management Work Package (WP10) has been included in the work breakdown structure to allow implementation of the management procedures. This WP covers all manpower needed for the overall coordination of the project and dissemination of the results within the consortium.

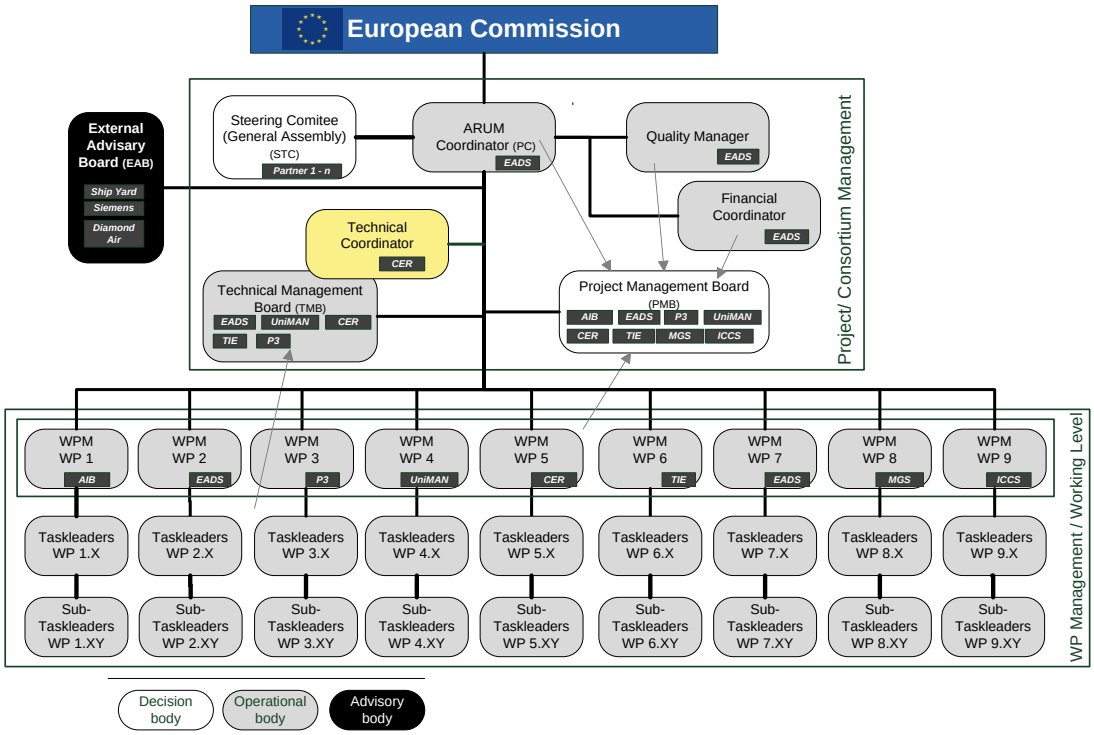


FIGURE 29: ARUM ORGANISATIONAL BREAKDOWN STRUCTURE (OBS)

Project Management Structure

The organisational structure of the consortium ensures a democratic decision making process. It comprises the Steering Committee (STC) as the ultimate decision-making body of the consortium and the Project Management Board (PMB). The Coordinator is the legal entity acting as the intermediary between the Parties and the European Commission. The Coordinator shall, in addition to its responsibilities as a party, perform the tasks assigned to it in the Grant Agreement and the Consortium Agreement.

The project management structure is shown schematically in the diagram in Figure 29.

The ARUM management structure is implemented within WP 10. Figure 30 shows the structure in detail.

The Technical Coordination will be conducted within the frame of the WP activities (WP 1 – WP9).

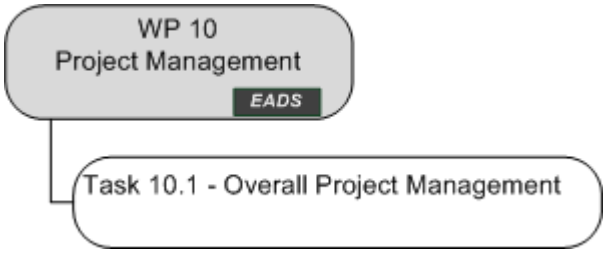


FIGURE 30: STRUCTURE OF PROJECT MANAGEMENT (WP10)

Role of each Project Management body

Project Coordinator

The Project Coordinator (PC) is responsible for the overall coordination, monitoring and supervision of all organisational and content-related project issues. The coordinator will have the responsibility for the day-to-day management and coordination of the project.

The PC acts as the single-point-of-contact between the consortium and the European Commission (EC) and with any third party. Progress reports will be sent every 12 months to the EC.

The PC will be responsible for signing the Grant Agreement with the EC, keeping records and financial accounts of the disbursements and informing EC about the distribution of all financial contributions. The timely collection and management of periodic financial reports and audit certificates from all partners will be guaranteed. To ensure sound and seamless project management in all budget issues, the PC will be assisted by a Financial Coordinator.

The PC will be responsible for drafting and updating the consortium Agreement, also for monitoring compliance by all partners with their obligations under the Grant Agreement and the consortium Agreement. The PC organizes and chairs meetings of the STC and the Project Management Board (PMB) including reporting service prior to each meeting of these project bodies.

The PC monitors and manages possible project risks and if necessary puts into effect measures to avoid substantial threats to a sound project implementation. The PC will appoint a Quality Manager to ensure monitoring and assessment of project progress according to proven quality standards.

The Coordinator will prepare a project management plan in month 1 which will detail the organisation of the management within ARUM.

Arnd Schirrmann (EADS) will act as the Project Coordinator.

Steering Committee (General Assembly)

The Steering Committee (STC) is the ultimate decision-making body responsible for giving final approval for all key contractual, financial and administrative issues concerning project and consortium. The STC will be in charge of supervising the progress of the project and particularly taking decisions of major and strategic relevance.

All partners signing the Grant Agreement will have a representative and a voting right in the Committee - one representative / vote for each partner, with each representative naming a deputy. The partners' representatives shall belong to the management level of their organisation not performing operational work in the project.

STC decisions are taken by consensus whenever possible. Should consensus not be achieved, decisions are taken on basis of a majority vote, favourably by vote of two thirds of the members. Detailed voting rules will be laid down in the consortium Agreement. The STC will meet once every 12 months. If necessary, additional ad-hoc meetings are possible - in urgent and exceptional cases

online meetings via webcam or any other suitable interactive communication tool may also be convoked.

The Project Coordinator will be responsible for organizing and chairing the STC meetings. At least 14 days prior to each STC meeting the Project Coordinator will send the annual progress report to the STC members with all key administrative consortium and content-related issues which are needed for decision making and final approval

Project progress reports will be sent to the STC by the PC at 6-months intervals. If the need arises, Work Package Managers and Task Leaders will be asked to attend the STC meetings to give specific reporting. The STC will thus be informed about the progress of the project and have the necessary authority to investigate any action, and if necessary to have extra-meetings, possibly by phone/video conference.

Financial Coordinator
The Financial Coordinator ensures the overall administrative and financial coordination of the project. The Financial Coordinator will assist the PC in all matters related to the implementation of EU grant roles and related reporting duties.

Quality Manager
A Quality Manger will be appointed to ensure continuous assessment and improvement of work flows, internal cooperation processes and project results. The increase of efficiency in project work leading to higher project quality is a major quality management goal. The Quality Manager will apply adequate control and adaptation measures on basis of international and European standards, as e.g. EN ISO 9001 / 9004 and ISO 10006. The QM will frequently report to the PC, PMB and STC. All quality measures intend to either prevent or minimize possible project implementation risks. The organisation of the IPR management will also be coordinated by the Quality Manager; close cooperation with the PC, STC and the PMB will be ensured.

Project Management Board
A Project Management Board (PMB) will be established by the 9 WP Managers, the Financial Coordinator and the Quality Manager to support the work of the PC. PMB members will have to attend conference calls every three months and meet at least twice per year regardless further individual Work Package meetings. The PMB will have overall responsibility for monitoring the work programme, reviewing technical objectives, risks, milestones and progress achieved, financial planning and control, exploitation and discussing corrective action where necessary. The PMB will also provide a framework for handling the IPR issues and holds general responsibility for dissemination issues.

Technical Coordinator
The Technical Coordinator (PC) is responsible for the overall technical coordination, monitoring and supervision of all technical and content-related project issues. The coordinator will have the responsibility for the technical management and technical coordination of the project.

Prof.Vladimír Mařík (CER) will act as the Technical Coordinator.

Technical Management Board
A Technical Management Board (TMB) will be established by the WPMs of WP 3 (P3), WP 4 (UniMan), WP 5 (CER) & WP 6 (TIE) and by a representative of EADS. The TMB will be lead by the TC.

In parallel with the classical technical management of the different WP, the TMB will ensure the technical coherency required by such integration project. TMB will meet on a regular basis at least each 3 months, either by video or telephone conference or meetings.

WP Managers –Task Leaders
Due to its complexity the ARUM project is based on a two-level Work Package-structure with main WP (WP x) led by WP Managers and subordinated Tasks (Task x.y) coordinated by Task Leaders (TL). The Work Package Managers (WPM) have been selected for their long-term expertise, research capacity and organizational abilities. They will be responsible for day-to-day coordinating, monitoring and reporting of the WP. The WPM will present deliverables according to plans, inform the PC about any deviation from plans in time or quality and implement necessary actions to avoid success risks. WPM will initiate and chair all necessary meetings within their WP and attend meetings with other WPM including those of the PMB.

Each subordinated Task will be coordinated by a Task Leader (TL) who is an experienced technical manager. TL will be responsible for detailed coordination, planning of work, monitoring, coordinating and reporting of tasks. The TL will nominate and supervise sub-task leaders (X.WZ).

External Advisory Board
The ARUM approach is particularly end-user driven which is reflected by the consortium composition itself. Nevertheless, the establishment of an Advisory Board consisting of representatives from end-user / EU commission strengthens the role and practical expertise of the end-users and increases visibility among the target group.

The Advisory Board will be informed by the PC on the project's status-quo and in particular on the development of major outputs and milestones via reports at a 6-month interval. The Advisory Board will meet every 12 months, preferably parallel to main consortium meetings (month 13, 25, 37). Online consultations among the members of the Advisory Board in-between the meetings will be enhanced.

The Advisory Board members develop interim reports on a 12-month basis as well as ad-hoc proposals concerning the orientation of practical, end-user relevant decisions and technological solutions. Frequent exchange with the STC and the PMB will be established.

Project Reporting, Planning, Progress and Control
The Project Management Plan that will be established by the PC at the beginning of the project will include an internal control and reporting scheme based on reporting templates. They will enable partners to produce the required information to the WPM who will review and collate them and forward them to the PM/PSO for incorporation into the formal reports. It will be the responsibility of the PC to collate, review and issue these formal reports (*to the partners and*) to the EC.

Decision making process

The role of the key management bodies of the IP in the decision making process is outlined hereafter:

	Steering Committee	**Technical management Board**	**Project Office**	**Exploitation Board**
Project‘s budget allocation	D			
Changes in terms of the EU Contract	D			
Expel defaulting parties	D			
Assign the Defaulting Party's tasks to specific entities	D	P		
Integration of new Contractors	D			
Press releases and joint publications by the participants	D	P	A	A
Detailed technical work plans & roadmaps		D		
Plans for using and disseminating the Knowledge	D	P	P	P
Day-to day administrative measures & operational controls	A		D	
Interface with EC	D		A	
Overall Project Plan	D	A	P	
Progress and milestone reports	D	P	P	
Cost statements	D		P	
Deliverables / Technical reports	D	P	A	

Strategic project issues	D	A		A
Scientific / technical methodologies, technologies / equipment to be used	A	D		
Project calendar, meetings and related documentation		P	D	
Consortium Agreement & IPR issues	D	A	A	P

Type of involvement Advice (A), Propose (P), Decide (D).

a) Methods for monitoring and reporting progress

Every 3 months, the PC will organize a teleconference with PMB members in order to exchange on any relevant topic (technical, financial, administrative), evaluate progress and follow all open actions.

To strengthen internal control mechanisms additional reporting duties on half-year basis between PC and project partners will be agreed (laid down in the consortium Agreement). In that respect the PC will collect technical status reports from WPM and WPL and budgetary reports from all partners. A synthesis report will be established and sent to the STC. These six-monthly reports will include an overview of the technical progress and deviation from plans as regards milestones / objectives achieved during the period. A work plan for the next period, following-up and updating of IPR and an annex with compiled reports of each partner will also be included.

Every 12 months, the PC will send a Management Report to the EC. This report will include a short overview of the technical progress and deviation from plans as well as the future work planned and action to be taken (if any). Cost statements and technical reports will be collected from WPM and WPL and compiled every 12 months by the PSO and sent to the Commission and partners. The reports will also give an assessment of current technical problems, suggest necessary actions and give costs estimates of such actions. The PC will regularly update staff, deliverables and milestone plans according to the data received. The PC will also coordinate the preparation of final reports and subsequent reports on exploitation of results.

Deliverable and Milestone Review and Assessment

WPM and PC will review and assess each project deliverable (under the responsibility of the relevant TL) before submission to the EC. If necessary, feedback will be provided to the author of the deliverable so that amendments and changes can be made. When a milestone point is reached, the responsible partner will be required to produce a brief report mentioning criteria for milestone assessment. Milestone reviews will be held at each meeting of the PMB where the progress of the project will be critically assessed and compared to the overall Work Plan / the Grant Agreement. Depending on the progress and results, necessary actions may be proposed by the Steering Committee, which may change the Work Plan in agreement with the Commission. If the technical progress is clearly deviating from the plans, and the prospects for successful completion of the project are poor, the STC can decide to discontinue the project.

A kick-off meeting, gathering all partners, will be organized at Month 1. A Mid-Term Assessment meeting will be held at the end of month 24 with all partners and the Commission representatives. The purpose is to report on the progress to date and to redefine (if necessary) the program for the remaining part of the contract. Procedures for managing future exploitation of results will be discussed and assessed.

A Final Review will occur on completion of end contract, drawing the scientific conclusions from the project and defining the process by which the technology will be implemented within the participating organisations. To ensure an unbiased view, the Project Coordinator and Work Package Managers will carry out the final review to report on the overall project performance.

Communication strategy

Internal Communication: members of the consortium will be guaranteed access to all documents produced within the project. In order to increase the level of synergy of cooperation, this open information flow policy towards all partners will extend to project status and all other relevant issues. The PC will be responsible for distributing all appropriate information from reports, minutes of meetings, etc. directed to him from the other partners. Technical means as e.g. the usage of an internal file and collaboration platform and the extensive use of online media will support the internal communication efforts.

External Communication: the project will communicate with other parties or consortia (e.g. The Foundation for the smart Factory of the Future (FOFdation) FP7-2010-NMP-ICT-FoF led by Airbus SAS), where appropriate, and will participate in activities when relevant information is available for the project. The project homepage, extensive publication of results, participation at relevant seminars, workshops and conferences on behalf of the project will be developed. All communication measures will be assessed by the Quality Manager and reported to the STC members; important decisions will be taken in the STC meetings.

B 2.2 Beneficiaries

EADS Deutschland GmbH, Innovation Works (EADS)

EADS (European Aeronautic Defence and Space Company) is a global leader in aerospace, defence and related services. (www.eads.net)

In 2008, EADS generated revenues of € 43.3 billion and employed a workforce of about 118,349. The EADS Group includes the aircraft manufacturer Airbus, the world's largest helicopter supplier Eurocopter and the joint venture MBDA, the leading international missile producer in the global market. EADS is the major partner in the Eurofighter consortium, is the prime contractor for the Ariane launcher, develops the A400M military transport aircraft and is the largest industrial partner for the European satellite navigation system Galileo.

EADS Innovation Works (IW), with sites in Germany, France, Spain, United Kingdom, Russia, Singapore and India provides world-class research capabilities in main aeronautics research topics such as materials, processes, structure engineering, systems and information technologies for engineering and innovative concepts. It is an operational and strategic asset for creation of added value for EADS by driving innovation and sharing skills, facilities and research activities with EADS Business Units (as core actor within the EADS Research and Technology network) and with external

research organisations and universities as well as other industrials. Long term partnerships with external research organisations, and in particular with academic laboratories, is a key element of the innovation strategy of the Group and of IW, evidenced in some areas by the creation of joint research laboratories.

The EADS Innovation Works in Germany is legally an organisation within EADS Deutschland GmbH, the German subsidiary of EADS N.V. It has a permanent staff of about 300 people, 70 % of which are senior scientists. Its objective is to carry out research activities, which require a concentration of skills or equipment and which correspond to cross-Business-Units.

The UK colleagues from Innovation Works are legally organized as EADS UK Ltd. Resources in Innovation Works UK, especially for development of manufacturing simulation models in WP 2 the EADS UK Ltd. may be used by EADS. For that EADS will bring UK Ltd. as a third party into the ARUM project.

Role / involvement in the project
EAD will be the Project coordinator, manager of WP2 and WP7, leader and/or contributor of several technical tasks, dealing with requirements, requirement engineering, architecture, integration and validation and demonstration and benefit assessment.

Brief introduction of key personnel for ARUM

- **Arnd SCHIRRMANN** is a graduate of the University of Technology Hamburg-Harburg (TUHH) (1995) and is been Research Team Leader of the “Services, Maintenance & Logistics” team of EADS Innovations Works (IW). He has previously worked as a scientific assistant at the TUHH and as a researcher for the DaimlerChrysler AG. His experience includes project management of national and multinational multi partner context (e.g. WPM within EU projects TATEM and e-cab).
- **Stephan TIECK** is a research expert at EADS IW. He holds a diploma degree in mechanical engineering from the TUHH. In the past he focuses on analysis and optimization of logistic and Supply Chain processes. He has been directly involved in working and managing of national and multinational projects.
- **Dr. Helge Fromm** graduated from the University of Hamburg, he has a Master of Business and Engineering (MBE) and he obtained his PhD in Engineering from the Technical University of Darmstadt in the field of assessment of innovative concepts (2009).
- **Alexander BIELE** is a researcher at EADS Innovation Works. He holds a diploma degree in mechanical engineering from the University of Technology Dresden. His research work is focused on the field of production ramp-up management for new aircraft products.

Airbus Operations GmbH – (AIB)

AIRBUS designs, sells, builds and supports the most modern and comprehensive aircraft family in the world thanks to·unrivalled flexibility across four aircraft families, all of which have been developed in response to customer needs, 56,000 employees around the world, including France, Germany, Spain, the UK, North America, China, Japan and Russia, a global network of over 296 customers and 298 operators and close working relationships with its shareholder EADS. Airbus achievements by the end of 2007 included: annual turnover of 181,1 Mds USD, gross market share (units) of 51 %, delivering 453 aircraft and selling 1,341 in 2007, surpassing 8,000 aircraft ordered by 286 customers, supporting 5,000 aircraft in service with 287 operators, regularly achieving over 50% of large civil aircraft orders and deliveries.

References relevant to ARUM

Airbus believes in investing in partnerships, research, new technology and training that benefits not only Airbus, but the wider industry and emerging economies. Airbus has a central role in a range of industry-wide research projects including Vision 2020, TANGO, SILENCE(R), and AWIATOR

Airbus leads the FP7 project (FP7-2010-NMP-ICT-FoF) The Foundation for the Smart Factory of the Future (FOFdation)

Role / involvement in the project

Within ARUM AIRBUS will be strong representative of the industrial end-user community. Airbus will contribute and lead the WP 1 “End-User Requirements and will intensively work on the definition of the “Aircraft Manufacturer Use Case. Furthermore Airbus is involved in the ARUM trials, assessment, benchmark, end-user validation and of course demonstration, dissemination, standardisation & exploitation.

Brief introduction of key personnel for ARUM

- **Bernard Duprieu** works in the Center of Competence “Manufacturing Engineering” of Airbus. He is responsible for R&T for industrial realisation of future aircraft programmes. Within this function he leads the Airbus department “Generic Technologies”

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CERTICON a.s. (CER)

CertiCon, a.s. is a an ICT company established 1996 in Prague, Czech republic.

Currently, there are 115 employees of the company, located in Prague and Pilsen, Czech Republic. There are 90 SW architects, developers and test engineers emploed at Ceticon.

The main long-term customers of CertiCon are Medtronic Inc. (pacemaker SW), Teradyne/SPX (diagnostic SW for automotive industry), Frequentis (mobile communication systems), Bosch (automotive), IBM (complicated database systems).

CertiCon participated already in 6 EU research projects as industrial partner and has quite a positive track record at EU authorities.

CertiCon has intensive experience in development of multi-agent based solutions, e.g. it developed the planning and assembling system for the engine assembling line for SKODA car manufacturer (more than two years in real-life operation), scheduling system for LIAZ Liberec (truck manufacturer), capacity planning system for handling sudden changes in capacity planning for Cadence Corp., supply chain management system for Chatzapoulos (a Greek company distributing food) etc.

References relevant to ARUM

Involvement in projects relevant to ARUM - EU:

• ECOLEAD European Collaborative Networked Organisations Leadership Initiative (2004-2007)

• PeLoTe- Building Presence through Localization for Hybrid Telematic Systems IST-2001-38873 (2002-04)

• GOAL Geographical Information On-line Analysis EC Joint Research Program INCO-COPERNICUS 977091 (1998-2001)

• ExPlanTech EC Joint Research Program IST (TRIAL) (2000-2002) novel multi-agent production planning technology for project oriented production

• ExtraPlanT EC EUTIS/AMI cluster project IST (2002-2003) extends ExPlanTech multi-agent technology for extra-enterprise (EE) production planning

Role / involvement in the project

CertiCon will be the Technical Coordinator of ARUM.

Certicon will be the leader of the WP 4 Methods & Tools for automated Control & Optimization. Certicon will manage the tasks within the WP4 as well as deliver substantial part of the SW development work.

Brief introduction of key personnel for ARUM

- **Prof.Vladimír Mařík**, CEO, Full Professor at the Czech Technical University since 1990, Chairman of the Research Council of the Czech Republic Technology Agency, Editor-in-Chief of the IEEE Trans. System, Man and Cybernetics, part C since 2005.

- **Vladimír Kozák** MSc, Chief Technology Officer Global Development & Services
- **Dipl. Ing. Martin Klima**, Ph.D. works in CertiCon a.s. as a Research and Development Manager. He focuses on research projects in the area of distributed systems, web technologies and human-computer interaction.
  2001: Master degree at Czech Technical University in Prague
  2009: Ph.D. at Czech Technical University in Prague
  Research and work experience:
  2001-2002 Zentrum in Graphische Datenverarbeiten, Darmstadt, Germany - worked as a researcher, adaptive mobile agent systems.
  2002 - 2012 Czech Technical University in Prague - worked as assistant professor in Department of Computer Graphics and Interaction
  2012 until now - CertiCon a.s.
  He is author and co-author of more than 20 scientific publications.

Iaccubucci/ Modular Galley Systems AG (MGS)

IACOBUCCI HF Group is a leading manufacturer and supplier of galley inserts worldwide.

The Group represent excellence in engineering, manufacture, design and innovation of Espresso and Coffee Makers, Water Heaters, Trash compactors, Trolleys and Ovens for commercial and business aviation.

The group is composed by different production sites:

- IACUBUCCI HF and IATS headquarter including the R & D centre of excellence Ferentino – Italy
- Industrial site in Lecce – Italy
- Industrial site in Patrica - Italy
- MGS AG in Elchingen – Germany
- hs2 engineering GmbH - Germany

MGS was founded in Germany in 2004 when its first product, the Induction Heating Unit (IHU) was successfully completed.

MGS is a young and engineering driven company. The best engineers are working on developing the newest Galley Inserts and Functional Inserts to provide new and easy to handle solutions to our worldwide customers. Especially for VIP customers an Inductive Hot plate was developed which is based on the same technology as the Multi-Functional Unit but is designed as a big Ceran cooking top and allows free cooking as in restaurants on ground. MGS truly became the specialist for inductive cooking on board. MGS also offers services for hard- and software development in the area of embedded systems and tool development.

The Iacobucci group had a turnover in 2010 of 23,4M€ with 185 employees. MGS had a turnover in 2010 of 2,5M€ with 20 employees.

In 2012 MGS has moved their engineering capabilities into the new subsidiary hs2 engineering GmbH. To use engineering resources out of that new subsidiary and resources of IACUBUCCI industrial site in Patrica for the industrial use case, MGS brings h2 engineering GmbH and IACOBUCCI HF Electronics S.p.A. as third parties into the ARUM project.

References relevant to ARUM

"IC-RFID Airline Catering" project: MGS participated in the ICRFID project (2009 – 2010). The title of the project was: Implementation and demonstration of a company wide intelligent service system based on RFID technology considering the whole process chain. The use case was the airline catering process.

Role / involvement in the project

MGS was responsible for several working packages as "Novel Cabin Services" and "Demonstration". In addition to this MGS developed hardware solutions and also software tools as part of the logistic chain.

Brief introduction of key personnel for ARUM

- **Karl-Heinz Haas**, Diplom Physiker, Head of Design at MGS, experience in several research projects (ICRFID for MGS and for the former mother company of MGS: Smart Galleys, ACS Advanced Catering System as European Project).

- **Verena Schwarz**, Diplom Mathematic, Quality Assurance at MGS, support of several research projects and program management for the A350 program.

Tie Nederland B.V (TIE)

TIE Holding N.V. is an international B2B software company, established in 1987, and focused on 'Connecting Businesses'. TIE (NYSE Euronext: TIE Holding) is an SME and also a publicly held company with offices in the United States, France, and the Netherlands (HQ).

TIE enables companies to do business electronically and to lower costs by synchronizing their product information and business processes with their partners in the Supply Chain. TIE helps industry and supply chain partners to achieve electronic business collaboration with solutions in the traditional and upcoming markets such as Business Interoperability, Data Quality Management, e-Invoicing, Master Data Management, Web Shops and Digital Channel Communications including Content Syndication. TIE's solutions are proven to lower costs, increase revenue and optimize business processes.
TIE serves the market for B2B eCommerce integration software with a clear focus on the inter-company processes (order, shipping, payment, etc.) based on globally accepted standards. This market continues to grow to include business process management, and data transformation. TIE has responded to increased market demand with new products, services, and partnerships. TIE's Kinetix platform provides a next generation eCommerce system allowing all partners of the supply chain to communicate with each other seamlessly. Within this area, TIE can benefit from its long experience with the Digital Channel concept which connects different business partners and helps them to exchange information.
TIE Holding N.V. will use workforce from the affiliated company TIE Holding N.V.Specific competences for the project:

TIE has been/is active in several EU projects including SEEMseed, SEAMLESS, STASIS, NEXOF-RA, SOA4ALL, NET-Challenge, NESSI2010 and in the FOF domain Adventure and Premanus. It has acted as work package and task leader and has project managed the very successful STASIS project . TIE (Stuart Campbell) is currently lead of the Technology Watch task force of the FINES cluster which is also related to FOF activities

In addition, TIE is Board Member, Steering Committee Vice Chair and SME lead of the NESSI European Technology Platform on Software and Service. In particular, NEXOF-RA is the core project for NESSI (and TIE is a partner) which aims at providing a reference architecture for software and services which is expected to be re-utilisable within the project. TIE is also a member of the NEM (Networked and Electronic Media) European Technology Platform.
Since its foundation in 1987 TIE has been active in B2B eCommerce, not only in application development but also in the standardization process and related for a including the United Nations CEFACT infrastructure and also the European Technology platform on software and services (NESSI).

Partner TIE Nederland B.V. is a 100% owned affiliate of TIE Holding N.V. and in turn TIE Holding N.V. 100% owns several other TIE affiliates. All these TIE Holding affiliates, as well as TIE Holding itself, have one consolidated set of accounts under IFRS. TIE Holding also has personnel resources, included Development and other resources. For resource flexibility, partner TIE Nederland B.V. may choose to use resources of other TIE affiliates. For that TIE brings to the project the following three third parties: TIE Holding N.V., TIE MamboFive N.V. and TIE Ascention DE.

Role in project
TIE leads the WP6 Integration.
Key Personnel

Stuart Campbell is the Chief Technical Officer of TIE. He is responsible for defining strategy, tactical planning, operational delivery and portraying TIE's technical direction and products. Stuart has been involved in the field of E-Business, since 1989. Stuart has held notable positions at ICL (now Fujitsu), the Western European EDIFACT Board based within the European Commission, the European Standards, CMASS and TIE. Stuart has produced several papers and regularly presents at conferences and forums such as XML Europe, COMPTIA, EDIFICE, and EAN events. He also managed the European EDI/XML technical assessment group for around 4 years which was processing around 2000 generally semantic related changes to the core E-Business standards in use today.

Stuart is chairing the SME committee in the European NESSI initiative and is Vice Chair of its Steering Committee. He also sits in the Future Internet SME group. Stuart has managed several large scale projects both internally within TIE (e.g. international product development, outsourced projects) and externally such as the aforementioned STASIS project.

Smart Solutions (SMRT)

The SMRT is a hi-tech SME (62 analysts and developers), founded in beginning of 2010 as a part of Knowledge Genesis Group (KGG), in Samara, Russia, operating in Germany, UK and US. SMRT is fully focused on developing new generation of multi-agent platforms and technologies for designing intelligent systems for real time resource allocation, scheduling, optimization and controlling. SMRT is developing industrial multi-agent systems for adaptive scheduling in aerospace, manufacturing, transport, railways and field services. As an innovative technology company the SMRT has accreditation from Russian Ministry of Science and Russian Aerospace Agency license on software engineering and programming for aerospace applications. It also has ISO 9001 certificate on quality of management. SMRT multi-agent systems for factory workshop management got "Best product of the 2011 year" prize on National Exhibition "Soft-Tool 2011" (Moscow, October 2011).

References relevant to ARUM

Company has competencies, knowledge and experience in bio-inspired holonic multi-agent systems for large-scale enterprises, ontologies for manufacturing, self-organization and evolution, adaptive resource allocation, scheduling, optimization and controlling.

"IC-RFID Airline Catering" project: Together with Airbus and EADS, MGS and Cologne University developers of KGG/SMRT participated in the ICRFID project (2009 – 2010) with the role to provide multi-agent platform and consultancy on developing intelligent RFID-based system for on-ground airport services.

KGG/SMRT team has started Magenta Technology (UK, London) in 2000 which has delivered industrial multi-agent scheduling solutions for zeppelins design company Cargo-lifter (Germany), biggest corporate taxi company in EU Addison Lee (UK), world-leading oil transport company Tankers International (UK), National truck logistics operator GIST (UK), rent-a-car company Avis (UK) and some others.

Now team is actively working in the area of intelligent manufacturing for world-known "Energy" Space and Rocket Corporation (Moscow), biggest producer of aviation devices Axion Holding (Izevsk), biggest jet production factory "Kuznetsov" (Samara) and others.

Role / involvement in the project

SMRT will contribute to the ARUM project mainly in WP4 and WP5 by design and implementation of ARUM platform, systems and tools. Besides the R&D activities, SMRT will provide free license for existing basic version of industrial multi-agent system for workshop scheduling for consortium partners. This version will be used for experiments and R&D activities and then will be advanced in cooperation with consortium partners and become solid basis for future commercialization, setting joint venture and distribution of new generation of intelligent manufacturing systems in Europe.

Brief introduction of key personnel for ARUM

- **Prof. Petr Skobelev** is the owner of KGG/SMRT and one of first scientists and entrepreneurs, who brought multi-agent technology from laboratory into industrial applications. His main research interest is intelligent systems based on multi-agent technology. He is member of the IEEE IES Technical Committee on Industrial Agents.
- **Prof. Vladimir Vittikh** – chief scientist specialized in theory of complex systems.
- **Prof**. **Sergey Smirnov** – chief researcher in ontologies for manufacturing.

- **Anton Ivashenko** has a PhD in Information Technologies. His research interests are intelligent decision support systems and knowledge based systems.
- **Alexander Tsarev** is a CEO of SMRT specialized on network-centric intelligent systems for production and transportation, p2p architectures, SOA and ESB solutions.
- **Andrey Lednev** is head of analytics centre specialized in analysis of requirements and in Manufacturing. He got MSc in Information Systems at the University of Surrey, UK.

Almende B.V. (ALM)

Almende is a high-tech research company (SME). It is a member of DevLab, an initiative of Dutch SMEs that have bundled their innovative strength in the fields of (wireless) embedded systems and related application domains.

Almende researches and develops self-organized critical agent-based solutions to sustain and improve the coalition formation and coordination of communication and collaboration across evolving networks of humans and existing ICT infrastructures. It investigates and applies and evaluates those agent-based solutions in many classical and novel problem domains.

References relevant to ARUM

- CREDO (IST-2006-033826), in which it develops and validates tools for modelling, verification and testing of (non-) functional properties of evolvable/dynamic structures within distributed hardware and software systems.

- REPLICATOR (IST-2008-216040), in which following principles of synergetics and renormalization it develops cognitive sensor fusion and emerging self-organized control modules capable of monitoring and controlling the morphology and dynamics of a robotic swarm / organism within changing environments.

- Distributed Engine for Advanced Logistics (DEAL; EETK01141) on robust and energy-efficient and eco-friendly distributed logistics management under dynamic incident of diverse severity.

- Human Hybrid Agent Networks (HHAN; CSI4006) on heterogeneous multi-agent systems taking ICT systems and humans in the loop for distributed negotiation, re-planning and co-evolutionary learning and optimization of multi-project resource-task assignments under dynamic service-request and environmental conditions in the airport ground handling service domain.

- SUPPORT - SUPporting and strengthening logistical networks in and around the PORT of Rotterdam - on robust and efficient distributed management of dynamic logistic networks involving terminals and freight forwarding networks in and around the Port of Rotterdam.

Role / involvement in the project

ALM will be contributor to technical tasks on the ARUM functional system architecture, the modelling of the ARUM multi-agent systems and the development and benchmarking of related robust and cost- and energy- efficient distributed dynamic multi-project scheduling algorithms for management of multiple concurrent manufacturing processes under diverse incident types, severities and cascades.

Brief introduction of key personnel for ARUM

- **Alfons H. Salden** holds a M.Sc. in Experimental Physics (1992) and a Ph.D. in Computer Vision (1996) on scale-space theory from Utrecht University. He has been and is involved in CREDO, REPLICATOR, DEAL and HHAN.
- **Andries Stam** holds M.Sc and Ph.D. in Computer Science from the University of Leiden on the behavioural modelling of evolving distributed systems in 2010. He has been and is involved in CREDO and SUPPORT.

Cologne University of Applied Sciences (CUAS)

Cologne University of Applied Sciences includes 12 faculties and 22 departments, running a large variety of R&D-projects in cooperation with industry. The Faculty of Economics and Business Administration leads back to one of the earliest business schools in Europe, founded 1904. The Research Centre for Applications of Intelligent Systems (RAIS) was started in 2007 as branch of the Research Centre for Knowledge Management (2003). It unites experience in research and consulting on real-time logistics, business analysis, knowledge-based and intelligent operations management, intelligent pricing, innovation and management of complex service system with a focus on the support of SME and SEM networks as well as on applications of multi-agent systems in different domains of aviation industry.

References relevant to ARUM

- iC-RFID (2010) – design and realisation of MAS prototyping functionality of RFID-based real-time management of air-catering systems (specification of fleet / aircrafts, operations network, airport infrastructures and including processes of service definition, apron field processes, catering assembly, apron transport, load exchange, and equipment rotation.
- "Knowledge Integrator" (2002) – MAS for shared "knowledge building" by simulation of economic and technological interdependency across a complex venture in aviation incl. benchmarking against conventional simulation (MAS realisation: Knowledge Genesis)
- ITS – Intelligent Truck Scheduler (2011) – testing of operativeness of a real-time MAS-based transportation scheduling platform for industrial project logistics and management of virtual fleets of trucks (MAS platform: Smart Solutions, Application partner: Le-Mark International, Controlling Chaos Technologies)
- RAIS collaborates since > 12 years with Knowledge Genesis / Smart Solutions and the Russian Academy of Sciences in Samara with regard to MAS design and application

Role / Involvement in the Project

In teamwork with EADS CUAS has developed the ARUM project and provided the models underlying the ramp-up management strategy to be implemented. CUAS is focused on

- elaboration of industrial use-cases, KPI as well as test- and acceptance scenarios,
- support of the design, standardisation and testing of ARUM platform and tools
- design of "professional services" for improving learning curves in ramp-up management
- implementation of Living Lab, exploitation for collaborative design, testing, dissemination

Short profile of Key Personnel

- **Dr. Dr. hc. Rolf Franken,** Professor for Management, Faculty for Business Administration. He was head of development of AI-based flight planning systems of Deutsche Lufthansa AG. Rolf was and is coordinator of a number of international and national projects (Tempus Tacis Project establishing the "Institute for Management, Economics, and Law" in Nizhniy Novgorod, RUS; ONE project on collaborative SME-networks). He focuses on applications of distributed Artificial Intelligence, intelligent organisations and company networks, innovation and knowledge-management.
- **Dip.-Oec. Udo Inden** lectures at CUAS since 1996 and co-director of RAIS (focus: project development and management). He was Director Strategic Research of Lufthansa Cargo (focus: global logistics and SCM, guideline for LHC service networks) and served in a consulting contract as Director for Logistics of the CargoLifter Project (focus: market-based integration of design & development of airship technology, operations, infrastructures, networks, economics, incl. global

lead-user program and market-based support of investor relations). He works as consultant on management of complex service systems and intelligent pricing. Udo initiated, consulted or managed more than 150 projects in applied sciences of a scale up to 400 Mio. €.. .

P3 ingénieurs S.A.S. (P3)

P3 ingénieurs SAS is an international provider of business services across mainly aerospace, automotive and tele-communication industries (www.p3-group.com). Apart from consulting services P3 offers engineering and testing services for complex electronic systems. Analysis and optimisation of industrial production systems is one of the key columns of the P3 consulting domain.

In 2010, P3 ingénieurs generated revenues of € 10 million and employed a workforce of about 40.

About 75% of P3 ingénieurs business is generated from projects across aeronautics industry. EADS with its daughters Airbus and Eurocopter is a leading customer of P3. P3 was able to help improving business processes in the field of production, supply chain and logistics as well as engineering and manufacturing engineering.

P3 ingénieurs' sister company P3 automotive – located in Stuttgart, Germany - runs a comparable portfolio of projects across worldwide automotive industry More than 50% of worldwide automotive OEMs are customers of P3 today. New production related projects have been launched with manufacturers of wind turbines, means of public transportation or car batteries over the past months. As a result a powerful basis for benchmarking and cross referencing of solutions for future aeronautic production systems can be guaranteed.

With the headquarters of aeronautic services in Toulouse P3 also runs fully owned SME subsidiaries in Hamburg/Germany, Madrid/Spain and Manchester/UK. All subsidiaries will be involved in order to secure a trans-European view on aeronautic production scenarios.

References relevant to ARUM

Conception of inspection strategies during ramp-up periods at aeronautic OEM's production plants for vertical tail plain parts and assemblies

Various projects on the improvement of production flows across aeronautics OEMs, conduction of MTM studies and lean manufacturing, six sigma methods

Smart Trash project: Co-lead of a EU funded study on potential use of RFID technology within waste industry and at the end of product life-cycle

Role / involvement in the project

P3 will take responsibility for the WP 200 "Ramp-up & Production Strategies" and will organise the preparation and capturing of production ramp-up strategies across different industries as well as the transfer of learnings into concepts for aeronautics. P3 will be selected for this dedicated work package in order to exploit the broad knowledge about production systems represented by the P3 customer base.

Brief introduction of key personnel for ARUM

- **Dr. Michael RÜBARTSCH** is a graduate of the University of Technology Aachen (RWTH) (1996) and is managing director of P3 aviation GmbH and président of P3 ingénieurs SAS. Before he worked as scientific assistant at the Fraunhofer-Institute for Production Technologies IPT, Aachen Germany. His experience includes industrial production and quality systems
- **Ingo SONNENBURG** is a P3 expert for the setup and execution of benchmarking studies and the creation of business models based on process modelling. In P3 aeronautic business he led such projects e.g within catering, cargo and duty free business or process landscapes for aircraft related data security.

- **Anton Czech** is a graduate of the University of Technology Aachen (RWTH) (1993) and is senior consultant and Project Leader for the P3 SAS. Before he worked as scientific assistant at the Fraunhofer-Institute for Production Technologies IPT, Aachen Germany. His experience includes Industrial production & quality systems, risk & change management.

University of Manchester (UNIMAN)

UNIMAN is currently 38th in the Shanghai Jiao Tong University world rankings. *The Centre for Service Research* has participated in a number of large EC- and EPSRC-funded research projects focusing their work on SOA and Web services, agent-based enterprise solutions, and agent-based optimisation of service ecosystems and urban mobility infrastructure. *The School of Mechanical, Aerospace and Civil Engineering* is one of Europe's largest engineering schools; the Management of Projects Group (MoP) specialises in research and postgraduate education in the defence, civil aerospace, power and transportation sectors. Staff within the school form part of the world-leading Dalton Nuclear Research Institute (winner of Queen's Jubilee Award 2011) and the Aerospace Research Institute (UMARI).

References relevant to ARUM

FP7 project MODUM (2011 - 2014); UNIMAN is WP leader for agent-based optimisation models. FP7 project BonFIRE (2010 - 2013); UNIMAN is WP leader of an experiment on optimisation of service ecosystems on FIRE facilities. FP7 project SOA4All (2008 - 2011); UNIMAN contributions include user requirement gathering and analysis, design and development of semantic service-based platform, working on specific tools for composition optimisation and service personalisation. FP6 project SUddEN (2006 - 2009): UNIMAN coordinated the project and contributed with algorithms for agent-based dynamic formation of virtual organisations.

Role / involvement in ARUM

UNIMAN will contribute with the design and development of an intelligent service-based platform (iESB) to support agent-based and service-based tools. UNIMAN will lead WP4 (system architecture and interfaces) and contribute to technical tasks in other WPs, dealing with requirements, tools, validation, assessment and demonstration.

Brief introduction of key personnel for ARUM

- ***Prof. Nikolay Mehandjiev*** is a Professor of Enterprise Information Systems. He has participated or led the following projects in the area of intelligent manufacturing infrastructures and support: FP5 MaBE (2002 - 2005), FP6 CrossWork (2004 – 2006), FP6 SUddEN (2006 – 2009), FP7 COMMIUS (2008 - 2011), FP7 SOA4All (2008 - 2011), FP7 BonFIRE (2010 - 2013) and FP7 MODUM (2011 - 2014).
- ***Prof. Andrew Gale*** is Professor of Project Management with an interest in project complexity, risk management and design change decision-support. Since joining UNIMAN in 1990, he has attracted over £2m worth of research and consultancy grants. He is also Director of the industry-led PMPDP programme.
- ***Dr. Ilias Petrounias*** is a Senior Lecturer in Business and Competitive Intelligence. His expertise is focused on business process modelling and optimisation, uncertainty in information systems development and decision-making based on intelligent techniques.
- ***Dr. Richard Kirkham*** is a Lecturer in Engineering Project Management with an interest in whole-life costs, stochastic modelling and risk management of complex systems. He has previously led WPs in FP5 EuroLifeForm (2001-2004, Cranfield) and FP5 WINDS (1999-2002, University of Liverpool). He is currently leading (with Professor Andrew Gale), an enterprise risk management integration project for a major power manufacturer.
- ***Dr. Cesar Marin*** is a Research Associate specialised in Adaptive Systems. He has worked on SUddEN and has coordinated R&D contributions to the projects COMMIUS, BonFIRE and MODUM. He has experience in designing and developing adaptive systems, including intensive experimentation and data analysis.

- ***Dr. Usman Wajid*** is a Research Associate expert in Flexible Multi-Agent Interactions. He has worked on the projects SUddEN, COMMIUS, SOA4All and BonFIRE. He has experience in multi-agent systems development, agent interactions and negotiation.

Polytechnic Institute of Bragança (IPB)

The Polytechnic Institute of Bragança (IPB) is a Portuguese Polytechnic Higher Education Institution, founded in 1983. IPB is currently divided into five schools, embracing a wide area of knowledge and technology, including agriculture sciences, arts and sports, education and teachers training, informatics and engineering, administration and management, health, and tourism. Nowadays, the IPB offers 22 post-secondary technological programs, 42 undergraduate degree courses, and 38 master programs, all according to the Bologna Declaration. Since these areas of teaching and research have been strongly developed over the last years, the Institute has witnessed a parallel growth of its student population, reaching the number of more than 7,500 students in 2011.

IPB belongs to the group of Universities of Applied Sciences (UAS) in Europe, focused on the transferability of professional skills and the integration of applied research in their professional and technological education mission.

References relevant to ARUM

Besides the teaching activities associated to a high-education school, IPB carries out R&D activities, aggregated in several research groups. The group of Automation and Robotics comprises several researchers holding the PhD in complementary areas of the automation domain, namely production control, robotics, and multi-agent systems. The competences provided by this multi-disciplinary team address the research and application of modern technologies and paradigms to solve complex engineering problems. Particularly, the competences on multi-agent systems, holonics, scheduling, self-* properties, and bio-inspired techniques (e.g., emergent behaviour, swarm intelligence and self-organization), fits well the topics of the project proposal. IPB participates in the following ongoing EU projects:

- FP7 GRACE (Integration of Process and Quality Control Using Multi-agent Technology") [2010 – 2013]
- FP7 CONET (Cooperating Objects Network of Excellence) [2008-2012]

Role / involvement in the project

IPB will contribute to the ARUM project with its knowledge and experience in the domain of multi-agent systems and biological inspired techniques, by developing real-time adaptive holonic multi-agent schedulers and simulators. Additionally, it participates actively in the dissemination and standardization activities.

Brief introduction of key personnel for ARUM

- **Paulo Leitão** is Professor at IPB and head of the Department of Electrical Engineering of that institute. He has published more than 100 papers in international scientific journals and conference proceedings, and has participated in several national and international research projects, and Networks of Excellence. His research interests are in the field of intelligent and collaborative production systems, multi-agent systems, holonic control, reconfigurable factory automation, bio-inspiration engineering and High-level Petri nets. He is currently chair of the IEEE IES Technical Committee on Industrial Agents.

- **Paulo Matos** has a PhD in Programming Technologies and is Professor in the Department of Informatics. His research interests are related with software engineering and intelligent decision support systems, more specifically with knowledge extraction, ontologies design and logical inference systems.
- **José Barbosa** is a PhD student on intelligent production systems, studying the application of multi-agent systems and bio-inspired techniques to develop distributed, flexible and reconfigurable production systems.
- **Ana Pereira** has the PhD degree in numerical methods for optimization and is Professor at IPB. Her research interests are in the field of nonlinear optimization, semi-infinite optimization and global optimization.

Institute of Communication and Computer Systems (ICCS)

The Institute of Communication and Computer Systems (ICCS) is a private law body associated with the School of Electrical and Computer Engineering (SECE) of the National Technical University of Athens (NTUA), the leading academic university in Greece. It has been established by the Ministry of Education in order to carry out R&D activity in the fields of all diverse aspects of communications and computer systems and their applications in variety of fields. The Intelligent Communications & Broadband Networks (ICBNet) laboratory that participates in the project is an ICCS member lab and very active in R&D. ICBNet expertise spans across a variety of interrelated research fields, including software and service design, creation and provisioning, context-aware service engineering, multi-tiered applications and Web 2.0 technologies, intelligent systems and semantic technologies, security and privacy, middleware and distributed systems. ICBNet has participated in various EU projects, successfully cooperating with leading institutions in EU and presenting broad dissemination and standardisation activity.

References relevant to ARUM

The ICCS' ICBNet lab has significant experience in the areas of middleware, software and service engineering, security and privacy and semantic technologies, with more than 150 publications in the fields, as well as several recent and ongoing EU projects, including:

FP7 DEMONS (role: semantic middleware engineering for privacy protection, dynamic workflows orchestration & business process engineering) [2010 – 2013]
FP7 CONVERGENCE (role: semantic middleware & services engineering) [2010 – 2013]
FP7 inCASA (role: middleware for sensors-based healthcare monitoring) [2010 – 2012]
FP7 PRISM (role: semantic middleware engineering for privacy protection) [2008 – 2010]
FP6 SMS (role: context-aware software and services engineering) [2006 – 2009]
FP6 DISCREET (role: semantic middleware for privacy protection) [2005 – 2008]

Role / involvement in the project

Apart from leading the activities of WP9, ICCS will have contribution in the specification and development of the system architecture, especially the i-ESB, in particular focusing on issues related with interoperability, communications, security, SOA-based semantic workflows, security and information protection and contextual aspects of the system behaviour. A priority for ICCS is to embed these concepts to the ARUM ontological models.

Brief introduction of key personnel for ARUM

- **Prof. Iakovos S. VENIERIS** is a professor in the SECE of the NTUA since 1994 and director of ICBNet. His research interests are in the fields of distributed systems, service engineering, agent technologies, mobile communications and Intelligent Networks, internetworking, resource scheduling and allocation for network management, modelling, performance evaluation and queuing theory. He has over 300 publications in these areas.
- **Prof. Dimitra I. KAKLAMANI** is a Professor at the SECE, NTUA. She has published over 200 journal and conference papers and led and participated in several EU and national research projects. Her research interests span across different fields and include the use of Object-Oriented methodologies and middleware technologies for distributed systems and privacy-aware infrastructures, the development of visualisation and real-time simulation for solving complex, large modelling and optimisation problems.
- **Dr. Georgios V. LIOUDAKIS** is a senior research associate of the ICCS. He received his Dr.-Ing. degree from the NTUA in 2008. As a research fellow of the ICCS/NTUA since 2000, he has participated in several EU and national projects. His research interests include security & privacy, distributed systems, software & services engineering; he has several publications related to these fields. He is active in standardisation, especially within ETSI, and holds the *rapporteur* role in the ETSI ISG "Measurement Ontology for IP Traffic" (MOI).

Czech Technical University in Prague (CTU)

The CZECH TECHNICAL UNIVERSITY IN PRAGUE (CTU), founded in 1707, is one of the oldest technical universities and currently the leading technical university (eight faculties) in the Czech Republic with approx. 23000 students enrolled in engineering courses. CTU with over 1700 members of academic staff is also one of the largest research institutions in the Czech Republic.

The Department of Cybernetics (at the Faculty of Electrical Engineering) is recognized as an outstanding research center at the CTU. In 2000 the department received the *EU Centre of Excellence* award and in 2006 the prestigious *European IST Prize* by the European Commission. The Department includes over 80 academic staff and researchers, and over 30 Ph.D. students. The research focus covers the areas of distributed artificial intelligence, multi-agent systems, computer vision, machine learning and system diagnostics, data warehousing & data mining, and decision support systems, with main application areas in computer integrated manufacturing, production planning, and decision support systems. The department has been collaborating with multiple industrial partners including Robert Bosch GmbH, Rockwell Automation, Skoda Auto, Gedas, Cadence, Denso Automotive, BAE Systems, and others. It also extensively collaborates with defense industry namely with the European Office for Aerospace Research and Development, US Air Force Research Laboratory, US Office for Naval Research and Army Research Laboratory.

References relevant to ARUM

AgentLink III: A Co-ordination Network for Agent-Based Computing, EU FP6 - Coordination Action, 2004-2005

I*PROMS: Network of Excellence for Innovative Production Machines and Systems, EU FP6 - Network of Excellence, 2004-2009)

PANDA: Collaborative Process Automation Support using Service Level Agreements and Intelligent dynamic Agents in SME clusters, EU FP6 - STREP, 2006-2008

CONTRACT: Contract based Systems Engineering Methods for Verifiable Cross-Organisational Networked Business Applications, EU FP6 - STREP, 2006-2009

Role / involvement in the project

CTU will contribute by fundamental research, applied research and implementations dealing with multi-agent and holonic systems, agent-based computing, agent-based simulations, knowledge-based decision support systems for real-time production control, legacy manufacturing control systems integration, and distributed production planning and optimization. CTU will strongly help with the dissemination of project results through well-established international conferences (HoloMAS, IEEE SMC, INDIN, ETFA), journals (IEEE SMC, Industrial Informatics, Intelligent Systems, JAAMAS), societies (IEEE IES and SMC).

Brief introduction of key personnel for ARUM

- **Pavel VRBA** is the head of the Distributed Intelligent Control Lab at Rockwell Automation Research and Development Center in Prague and from 2011 the research fellow at the Department of Cybernetics within CTU. His research interest is in applications of multi-agent systems, simulations, and semantic technologies in industrial automation domain.
- **Petr Kadera** is a researcher and PhD student and at the Department of Cybernetics at Czech Technical University in Prague. His research interests include multi-agent systems, semantic technologies, distributed intelligent control systems, distributed diagnostics, and simulations.

University of Hagen (UniHa)

The FernUniversität in Hagen (UniHa) is currently one of the biggest universities in Germany, with some 74,000 students and 1,700 courses. The FUH is the German centre for distance collaborative teaching and learning in virtual communities, including development and use of respective solutions. Higher education provided by universities requires continual re-orientation. Having accepted this challenge, FUH is today a university of the future for a world of tomorrow.

FUH's Department of Mathematics and Computer Science, Chair of Enterprise-wide Software Systems: The research group, led by Prof. Dr. Lars Mönch is involved in research on information systems for manufacturing and logistics, multi-agent systems, planning and scheduling, and discrete-event simulation.In addition, the group has a strong background in simulation-based benchmarking of novel information systems for manufacturing and logistics.

The group is building on research expertise from a long standing history in collaborative research with different leading global semiconductor manufacturing companies, i.e., Global Foundries and Infineon Technologies AG. Furthermore, the group was involved in the German Science Foundation (DFG) priority program in business applications of agent technology.

References relevant to ARUM

German Science Foundation (DFG) priority program in business applications of agent technology (sub project FABMAS)

(government funded) BMWT project IcoTrans (sub project related to the development of a multi-agent system and overall project lead)

Role / involvement in the project

UniHa will be leader and/or contributor of several technical tasks, dealing with ramp-up strategies, architecture, scheduling, and simulation-based benchmarking issues of the proposed solutions.

Brief introduction of key personnel for ARUM

- **Lars Mönch** is professor and holds the Chair of Enterprise-wide Software Systems at the Department of Mathematics and Computer Science at the University of Hagen, Germany. He received a master's degree in applied mathematics and a Ph.D. in the same subject from the University of Göttingen, Germany. His current research interests are in simulation-based production control of semiconductor wafer fabrication facilities, applied optimization and artificial intelligence applications in manufacturing, logistics, and service operations. He was/is the leader and PI of several national and international research projects, funded by government and private companies.
- **Andrew Bilyk** is a research assistant at the Chair of Enterprise-wide Software Systems at the University of Hagen. He received a master's degree in applied mathematics from the National Ivan Franko University of Lviv, Ukraine. His research interests are in discrete-event simulation, parallel computing, and multi-agent systems.
- **Hanna Wenke** is a research and teaching assistant in the Department of Mathematics and Computer Science at the University of Hagen, Germany. She received a master's degree in applied mathematics from the University of Münster, Germany. Her current research interests are in scheduling and simulation in manufacturing, logistics, and service operations.

B 2.3 Consortium as a whole

Partnership

The consortium gathers 14 partners from 7 EU countries and Russia, including United Kingdom, Germany, France, the Netherlands, Greece, Czech Republic and Portugal. It associates an industrial Research Centre, Public Research Organisations, industrial companies and SME of various sizes and several end-users.

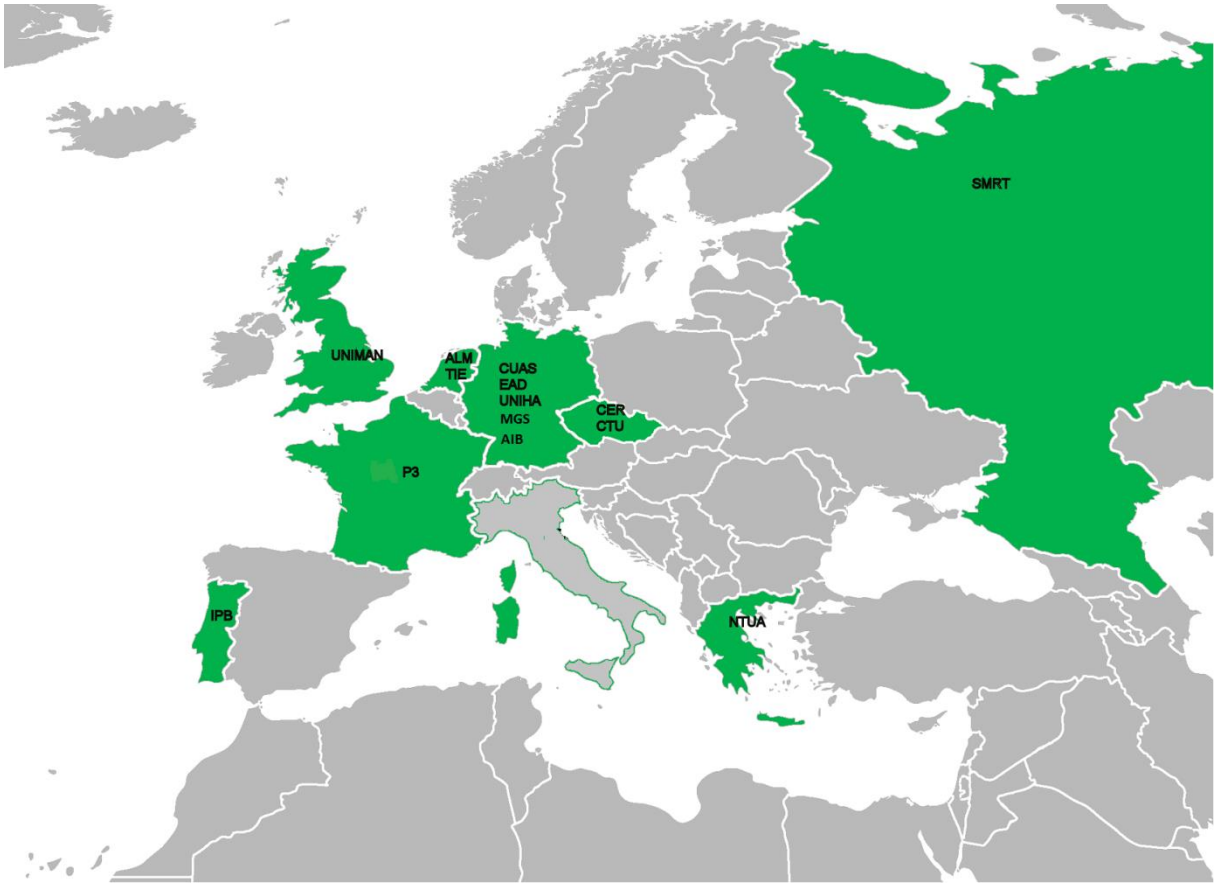

FIGURE 31: ARUM PARTNERS

The size of the consortium has been defined so as to keep it manageable and to ensure:

- a significant involvement of end-user's know how, whether direct or due to strong partnership / cooperation with end users
- the availability of all expertise required to define and assess the relevant concepts and solutions

The participants to the ARUM consortium have been carefully selected to provide the necessary combination of profiles, skills, experiences and capabilities needed to achieve the ambitious objectives and the expected impact of this Integrated Project with:

- the determination of the relevant scenarios and the concept,
- the definition of the system architecture, success critical technical elements,
- the integration of solutions for demonstrations,
- the evaluation of local technical solutions and of the ARUM end-to-end solution by simulations and real experimentations,
- the dissemination of the results to the large end-user community.

Table 5 shows the main characteristics & motivation of the partners to join ARUM.

No	Participant short name	Characteristics & Motivation	Country
1	EADS	EADS Innovation Works provides world-class research capabilities in main aeronautics research topics such as materials, processes, structure engineering, systems and information technologies for engineering and innovative concepts. EADS IW wants to push the ARUM approach and wants to spread the M&T within the EADS business units and aeronautic supply chain.	GE
2	AIB	EU leader in Aeronautics Manufacturing. Active contributor to standardization activities about digital factory. Strongly supports the project objectives that fully comply with Airbus needs from the big picture integration perspective. Airbus would like to contribute as strong representative of the industrial end-user community in all End-User Requirements and intensively work on the definition "Aircraft Manufacturer Use Case".	GE
3	CER	CER has an intensive experience in development of multi-agent based solutions. European research projects as industrial partner has a quite positive track record at European authorities. CER would like to manage the Methods and Tools for Automated Control and Optimisation as well as deliver substantial part of the Software development work.	CZ
4	MGS	The MGS group represent excellence in engineering, manufacture design and innovation of electrical equipment for commercial and business aviation to worldwide customers. They also offer services for hard- and software development in the area of embedded systems and tool development. MGS wants to involve their excellent experience in several packages for "Novel Cabin Services" and "Demonstration". In ARUM the group would also develop suitable hardware solutions and software tools as part of the logistic chain useful for its worldwide business partners.	GE
5	TIE	TIE Holding N.V is an international B2B software company focused on "Connecting Business". TIE´s solutions are proven to lower costs, increase revenue and optimize business processes, which is a great benefit outcome from its long experience with the Digital Channel concept for exchange of information between business partners. TIE would like to integrate owned experience in software development in the System architecture and Interfaces of ARUM to amplify its business fields. The group would also intensively involve in the integration process of overall systems.	NL
6	SMRT	SMRT an innovative technology company has accreditation from Russian Ministry of Ministry and Russian Aerospace license for aerospace applications. SMRT is fully focused on developing new generation of multi-agent platforms and technologies for designing intelligent systems. SMRT has competencies, knowledge and experience in bio-inspired holonic multi-agent systems for large scale enterprises, ontology for manufacturing, self-organization and evolution, adaptive resource allocation, scheduling, optimisation and controlling. Due to this they highly motivated to provide free licenses to consortium partners of ARUM for future commercialization, setting joint venture and distribution of new generation of intelligent manufacturing systems in Europe.	RUS

No	Participant short name	Characteristics & Motivation	Country
7	ALM	ALM is a high-tech research company bundled their innovative strength in the fields of (wireless) embedded systems and related applications domains. It investigates, applies and evaluates agent-based solutions and novel problem domains among which the logistics domain. ALM is interested in ARUM´s development of related robust and cost – and energy-efficient distributed dynamic multi-project scheduling algorithms for management of multiple concurrent manufacturing processes under diverse incident types, severities and cascades.	NL
8	CUAS	CUAS is running a large variety of R&D-projects in cooperation with industry. It unites experience in research and consulting on real-time logistics, business analysis, knowledge-based and intelligent operations management, intelligent pricing, innovation and management of complex service systems with a focus of multi-agent systems. CUAS in teamwork with EADS has developed the ARUM project. CUAS wants to push ARUM in the design of “professional services” for improving learning curves in ramp-up management and ARUM platform and tools. ARUM would be a further scientific interface between the Faculty of Economics and Business Administrations and the industry.	GE
9	P3	P3 ingénieurs SAS is an international provider of business services across mainly aerospace, automotive and tele-communication industries. About 75% of P3 business is generated from projects across aeronautics industry. Due to its key columns in analysis and optimisation of industrial production systems and the conception of inspection of strategies during ramp-up periods, P3 is highly motivated to receive new experience during ARUM in Ramp-up & Production Strategies.	FR
10	UMAN	The University of Manchester for Mechanical, Aerospace and Civil Engineering is one of Europe´s largest engineering schools, the Management of Projects Group specialises in research and postgraduate education in the defence, civil aerospace, power and transportation sectors. Staff within from part of the world leading Dalton Nuclear Research Institute and the Aerospace Research Institute. UniMan would like to boost ARUM in support of intelligent service-based platforms and technical tasks for new research results to deal with and teach in university.	UK
11	IPB	IPB a Portuguese Polytechnic Higher Education Institution focused on the transferability of professional skills and the integration of applied research in professional and technological education mission also carries out R&D activities, aggregated in several research groups. With several researchers holding the PhD in complementary areas of automation domain, namely production control, robotics and multi-agent systems, IPB wants to contribute ARUM with knowledge and experience in the domain of multi-agent systems and biological inspired techniques to result new techniques and methods.	PT
12	ICCS	ICCS, the leading academic university in Greece has been in established by the Ministry of Education in order to carry out R&D activity in the fields on all diverse aspects of communication and computer systems. ICCS wants to involve owned experience in the System architecture and interfaces to support ARUM. It´s highly interested in dissemination of the results.	GR

No	Participant short name	Characteristics & Motivation	Country
13	CTU	The research at Czech Technical University focus covers areas of distributed artificial intelligence, multi-agent systems, computer vision, machine learning and system diagnostics, data warehousing & data mining and decision support systems. In this fields it has collaborate with multiple industrial partners. CTU wants to push ARUM with fundamental research, applied research and implementation dealing with multi-agent and holonic systems. It is highly interested to strongly help with the dissemination of project results through well-established international conferences.	CZ
14	UNIHA	UNIHA is the German centre for distance collaborative teaching in learning in virtual communities including development and use of respective solutions. UNIHA is building on research expertise from a long standing history in collaborative research with different leading global semiconductor manufacturing companies. It wants to boost ARUM in contribution of several technical tasks, dealing with ramp-up strategies, architecture and simulation-based benchmarking issues of the proposed solutions to build up further experience within UNIHA.	GE

TABLE 5: CHARACTERISTICS AND MAIN SKILLS AND MOTIVATION OF EACH PARTNER

Involvement of stakeholders

The ARUM approach has found a very positive feedback in the end user community of Europe high tech industry. However, resources or company policies usually do not always allow them to participate as full partner in EC projects. Two end-users are direct involved in the consortium (AIB, MGS) and EADS as project coordinator also represents in its company function a large end-user group (EADS group includes Eurocopter, Astrium, Cassidian) with strong interest in ARUM results.
To enlarge the end user community, the consortium has proposed to industry partners to join our External Advisory Board (EAB). Beside the full commitment of the FGS shipyard and AviaAgregat (see Annex 1) several other companies like Diamond Air, Infineon, Rolls-Royce have shown interest to join the EAB.

Consortium experiences and complementarities of the partners

The achievement of the project objectives requires the availability of the following capabilities and knowledge:

- Domain knowledge in small lot production
- Domain knowledge in production ramp-up
- Process analysis and concepts development
- Experiences in Gap analysis & benchmarking
- Data aggregation & legacy system integration
- Knowledge representation / Ontologies
- Knowledge processing Multi-Agent Systems
- Enterprise Information Bus / SOA architectures
- Demonstration & technology assessment
- Benchmarking / Lab test bed
- Experiences in research project management

The following table maps the needed capabilities and consortium partners.

	EAD	AIB	P3	MGS	P3	UNIHA	TIE	CER	SMRT	CTU	IPB	CUAS	ALM	UNIMAN	ICCS
Domain knowledge in small lot production	x		x	x	x										
Domain knowledge in production ramp-up	x	x	x		x										
Process analysis and concepts development	x	x	x	x	x										
Experiences in Gap analysis & benchmarking	x	x	x	x	x	x									
Data aggregation & legacy system integration						x	x								
Knowledge representation / Ontologies								x	x	x	x	x			
Knowledge processing Multi-Agent Systems						x		x	x	x	x	x	x	x	
Enterprise Information Bus / SOA architectures						x	x	x			x	x	x	x	x
Software development and integration						x	x	x	x	x	x		x	x	x
Demonstration & technology assessment	x	x	x		x	x	x							x	
Benchmarking / Lab test bed	x	x	x		x	x	x								
Experiences in research project management	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

TABLE 6: MATRIX OF EXPERIENCES INSIDE ARUM CONSORTIUM

i) Sub-contracting and Third Party

A limited activity is planned to be sub-contracted, details are provided in Table 7.

WP	Partner	Type of subcontract	Justification	Amount
10	all partners	Financial reports / audits	Audit necessary whenever EC contribution exceeds 375.000€.	ca. 65.500 €
Sum				**€ 65.500**
% of total budget				**% 0,6**

TABLE 7: ARUM ENVISAGED SUBCONTRACTING

Within ARUM the partners TIE, MGS and EADS want to use resources from affiliated companies for resource flexibility and in order to achieve the envisioned tasks in an optimal way. The following third parties are involved and will deliver the following contributions to ARUM:

- TIE NETERLAND B.V. brings in the following affiliated companies as third parties: TIE Holding N.V., TIE MamboFive N.V. and TIE Ascention DE.

Affiliate	Type of resource	Likely WPs/Tasks
TIE Holding N.V. TIE MamboFive N.V.	Development Personnel	WP2, 3, 5, 6, 7, 9 (Chiefly T9.3, T9.4, T9.5)
TIE Ascention – DE	Marketing Personnel	WP9 (Chiefly T9.1, T9.2)

- MGS has moved their engineering capabilities into the new subsidiary hs2 engineering GmbH and wants also to include the Italian production plant operated by IACOBUCCI HF Electronics S.p.A. were the 2nd use case is located.

Affiliate	Type of resource	Likely WPs/Tasks
H2 engineering GmbH IACOBUCCI HF Electronics S.p.A.	Engineering and manufacturing specialists	WP2, 8, 7, 9

- EADS wants to add their UK sister company EADS UK Ltd., especially the resources of the UK Innovation Works for support in use case modeling and simulation in work package 2.

Affiliate	Type of resource	Likely WPs/Tasks
EADS UK Ltd.	Research specialists	WP2

Further details regarding the third parties and their involvement may be found in the individual participant pages of EADS, MGS and TIE.

ii) Other countries

The ARUM consortium consists of 13 partners EU-27, 1 partner from Russia.

The strong involvement of the Russian company SMRT as one of the major technology provider in ARUM is based on the following reasons:

1. SMRT is one of the world-leaders in designing industrial MAS for real time resource management and is working for aerospace, manufacturing, transport, railways and supply chains;
2. SMRT has successful experience in cooperation with EADS and Airbus, Cologne University in pioneering MAS platforms and solutions;
3. SMRT has growing academic activities with EU pioneers of bio-inspired holonic MAS - members of project (CTU, IPB, ALM);
4. Currently SMRT has unique software assets for intelligent manufacturing and will provide partners with the latest version of its adaptive MAS scheduler for workshops for free for adjustments, integration and customizations for use cases;
5. During the project SMRT will be heavily involved in design and implementation of core platform, systems and tools integrated in holonic multi-level p2p architecture - the key part of project;
6. The project will require a lot of software engineering and SMRT will provide a number of high quality and skilled Knowledge Engineers and MAS developers;
7. In cooperation with project partners - research and software engineering companies (CERT, ALM, TIE) - SMRT is interested in productization and commercializing project results by creating EU-based joint venture which can deliver solutions for intelligent manufacturing not only for EU market but also for US, Russia and China;
8. SMRT has success story of productization and commercialization of MAS for intelligent transportation by starting UK-based company Magenta Technology in 2000.

iii) External Advisory Board

Additional partners of the ARUM project are the end-user and stakeholder of the External Advisory Board (EAB). It is envisaged that these partners join the project as members of the External Advisory Board.

The total travel costs for the EAB members have been calculated for the project run time to 18.000 €. This estimation includes the travel costs to join the EAB meetings and the final demonstration

B 2.4 Resources to be committed

ARUM efforts

In order to achieve its objectives, ARUM requires a total of 1141 PM. The contributions of partners per work-package are dimensioned to map as efficiently as possible the required efforts with the targeted goals. Section 2.3 has shown that these efforts have been distributed among the different

types of partners to enable different research activities (dissemination, privacy awareness, network layers architecture, protocols, algorithms and test-beds):

- Industry: 18%
- Research: 36%
- SME: 46%

ARUM cost and funding

The overall cost of the project is 11.5 Mio. €. The requested funding contribution amounts to 8.49 Mio. € for the 37 months of the project. Figure 32 presents a fairly balanced cost and funding distribution among the different types of partners in the project (Industry, SME and Research). The budget for Industry is 25% of the total cost of the project (21% of the funding requested to the EC). SME participation is significant with 42% of the total budget (44% of funds requested). Research partners claim 33% of the budget, respectively 34% of funds. This balance in budget assures that ARUM concentrates efforts on the architecture design, implementation and demonstration of ARUM elements and thus eases its adoption for operators.

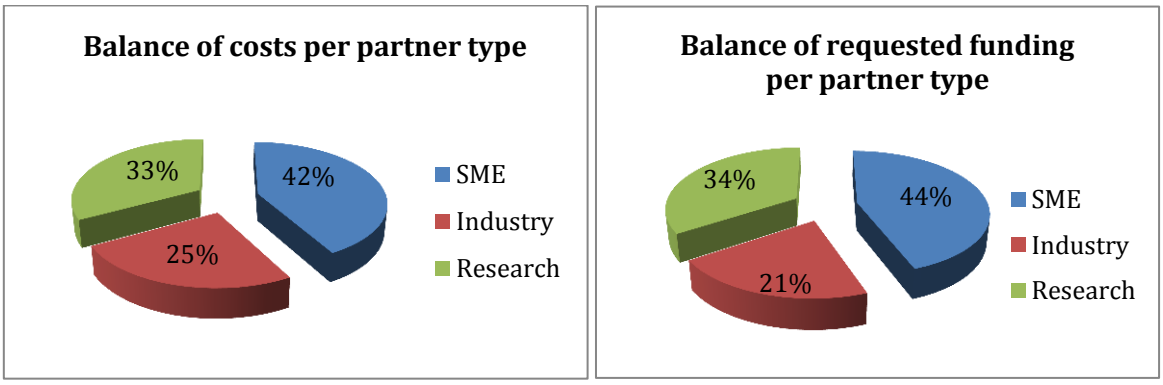

FIGURE 32: COST RATIO BALANCE PER TYPE OF PARTNER (IN TERMS OF BUDGET AND FUNDING)

Cost and funding distributions

RTD, MGT, OTH and DEM costs have been declared in the proposal as follows.

The table below presents the details of the cost and funding for the project:

	Cost (€)	EC contribution (€)
Research (RTD)	**8.453.320**	**5.874.615**
Demonstration (DEM)	**1.039.363**	**519.683**
Other (OTH)	**1.653.989**	**1.653.988**
Management (MGT)	**436.046**	**436.046**
Total	**11.595.249**	**8.489.679**

The overall funding rate of the project thus amounts to 72,6%.

The management costs represent the cost of all management actions (personnel cost and Indirect costs) for the project coordination and the costs for audit certificates. The management costs of roughly 436.000 € represent 3,7% of the total project cost.

The table below presents the details of the cost and % of total budget:

	Cost (€)	% of total budget
Personnel cost	**6.852.575**	**59,2%**
Other direct cost	**658.037**	**5,7%**
Audit certificates / Subcontracts	**65.500**	**0,6%**
Overhead	**4.006.605**	**34,6%**
Total	**11.595.249**	**100%**

- Personnel costs represent all staff effort needed to implement the ARUM actions.
- Other direct costs mainly comprise travel, equipment, dissemination and publication costs. These costs represent appr. 5,7% of the budget. Meetings, particularly SCT and Consortium meetings will be bundled to reduce travel expenses, other needed interactions will be done through phone and web conferences. Partners plan also travels for conferences and/or participations to standardizations bodies. Additional costs have been foreseen in the budget of the PC to support Advisory Board travel costs.
- Audit certificates: costs consist in sub-contracting for Audit certificates.
- Overhead: Total overheads costs arise from adding overheads costs of each of the partners, calculated according to their respective costs models.

Travel and other direct costs

The table below details the travel costs and consumables and other direct costs for each partner:

Partner	Travel	Consumables	Other direct costs	Comments
EADS	71.000		3.000	Including costs for EAB members travels
AIB	18.000		1.500	
CER	45.750	7037	3.000	
MGS	27.500		5.500	

TIE	47.000		38.000	The other direct costs are foreseen for dissemination: Material (Stand, Brochures etc.) and the workshop costs, maybe a CEBIT attendance fee, etc.
SMRT	35.000		1.500	
ALM	32.000		3.000	
CUAS	23.000		3.000	
P3	53.250		1.000	
UNIMAN	38.000		3.000	
IPB	23.000		3.000	
ICCS	30.000		7.000	
CTU	22.400		3.000	
UNIHA	29.000		11.300	

TABLE 8 COSTS: TRAVEL, CONSUMABLES AND OTHER DIRECT PER PARTNER

Additional equipment

ARUM partners limit as much as possible the costs for new equipment and software, relying on their own (present and past) investments to handle the new research and development activities. However, a few additional equipment or software licences have been identified as follows:

Partner	Additional cost	Justification
All partners	0 €	Most of the ICT development during the RTD will be conducted on existing SW & HW of the partners. Some partners nevertheless need to purchase some specific equipment.
EADS	15K	In order to be in a realistic, close-to-production environment, EADS Deutschland GmbH targets to invest 70k€ on their own for the ARUM equipment and trials (routers, servers …). Beside this, EADS requests 15 k€ for specific hardware dedicated to the project lifetime (NAS for traffic storage, analysis and replay; server capacity to handle the distributed multi agent system).
CER	5K	Specific, non-existing IT equipment for development
MGS	14K	Three non-existing high performance computers for simulation of workflow.
TIE	5K	Specific, non-existing IT equipment for development
CUAS	8K	CUAS plans “other costs” for contributing IT server capacity as well as conceptual and consultative user support for a living-lab with objective of academically as well as commercially motivated international dissemination of project result.

IPB	3K	Specific, non-existing IT equipment for development
SMRT	8.5K	Three servers to organize and test networks of schedulers, separate applications, DBMS
CTU	3K	Specific, non-existing IT equipment for development
UNIHA	7.8K	High performance computer for simulation, planning and scheduling

TABLE 9 RESOURCES TO BE COMMITTED

B3. Impact

The project ARUM will contribute towards the expected impacts listed in the Factories of the Future PPP roadmap. The project focuses on the R&D challenge "ICT-enabled intelligent manufacturing". Moreover, the business strategies & ICT technologies that will be proposed in ARUM are considered as a reasonable improvement thanks to the following advantages:

- Lean and easy-to-implement ICT
- Holistic systems, strategies and tools for an integrated intelligent control and dynamic optimisation of factory assets
- ICT driven approach with scalable architectures, easy adaptable for discrete, continuous or batch industry
- Efficient aggregation of information across existing legacy systems at all production levels
- Demonstrations & benchmarking of ARUM concept in real industrial environments under scenarios described from potential end-users.
- Dissemination and exploitation using a Living Lab approach

B 3.1 Strategic impact

Strategic Impact

Taking under consideration the overall project goals, a set of indicative KPI impact objectives have been defined. These impact objectives are presented hereafter in terms of target against existing solutions are presented, means to achieve, expected time frame and level of uncertainty.

	Objective	**Target**	**Means**	**Time-frame**[7]	**Uncertainty**
Ramp-up	Pursue of **ramp-up targets/ short time-to-market**	30 %	Implementing of innovative business strategies for holistic optimisation	4 years	Medium
	Reduce lead time increments during ramp-up caused by shortages of	40 %	Implementing of an intelligent ICT, that allows to minimize the effects due to adequate re-	4 years	Low

[7] From project start

	Objective	Target	Means	Time-frame[7]	Uncertainty
	parts.		planning (knowledge based)		
	Reduce costs increments during ramp-up caused by unplanned work.	10 %	Implementing of an intelligent ICT that allows to use resources (staff, facilities) more efficient and overall target -orientated	4 years	Low
	Set-up of **production system** for new products with an high **robustness** against **disturbances**	15	Develop, test & assessment of new production system set-ups	8	Low
Small lot production	**Reduction** of production planning **costs**	15 %	Implementing of an intelligent ICT that allows a knowledge based planning	3	Low
	Reduction of production **costs**	5 %	Implementing of an intelligent ICT that allows a more efficient usage of resources	3	Low
	Reduce lead time increments caused by shortages of parts.	5 %	Implementing of an intelligent ICT that allows to minimize the effects due to adequate re-planning	3	low
	Optimisation of **existing production** systems	10	Develop, test & assessment of new production system set-ups & logistic strategies e.g.	3	low

TABLE 10: ARUM STRATEGIC IMPACTS

Economic Impacts for Europe competiveness

ARUM will strongly impact the European competitiveness for industry and SME, by:

- tailored business strategies to answer adequately the today's challenges of manufacturing (sophisticated, complex products, highly customized, high variety, global supply chain, short time to market etc)
- an intelligent ICT supporting the application of the new business strategies
    - High information transparency along the manufacturing chain, by vertical & horizontal data cross-linking
    - Standardized interface for intelligent/ know-ledge based tools
    - Tools (risk assessment, scheduling, simulation) for production

The economic expected impacts are:

- a shorter time to reach the production ridge line during ramp-up– by real time event-driven scheduling, optimization and control of resources;
- shorter lead times – by real time event-driven scheduling, optimization and control of resources
- enhanced understanding of risks, detection of early warning and accelerated learning by real time simulations and analysis of bottle-necks;
- faster response to unexpected events by automated discovery of conflicts in schedules and solutions based on trade-offs "on-the-fly" (without system stop);

- enrichment of the base of information for decision making;
- support of situation-aware decision making process by real time scheduling and optimization of resources with analysis of options available and smart manual rework of previously made decision;
- active-based cost model with multi-criteria optimization including quality of services, delivery time, resource utilization, risks, etc
- enhanced opportunities for holistic assessment of new production technologies (costs, lead times, risks,..)
- enhanced opportunities to design, assess & benchmark production layouts for new or successor products

Impact on Manufacturing Industry under Ramp-up Conditions

The ability to conduct ramp-ups according to the initial planning is and will be in the future an important competitive factor. Especially the aeronautic industry has strong needs to improve their capabilities in this perimeter. Especially the increasing competition in this branch will require new solutions. A failed ramp-up under new market scenarios with new competitors (Chinese, Russian, and Brasilia) on the market can be very dolorously for the OEM and the supply chain.

Within ARUM the development of solutions to answer ramp-up requirements adequately will be conducted on an airframer use-case (Airbus: new aircraft ramp-up). Due to the envisaged open approach the ARUM solutions can be also applied to other manufacturing industries, like automotive, machine tools or railway industry. The approach can handle ramp-ups of all kind of products, they can be simple or complex and can be standardised or high customisable.

Impact on Manufacturing Industry and SME with Small Lot Production

Beside the ramp-up use-case the ARUM solutions can be also applied to manufacturing industry and SME with small series. The manufacturing systems of this kind of production are typically marked by high demands of flexibility and lack of resources. The planning and control efforts are typically very high, due to a missing stabile production state.

ARUM will offer solution for manufacturing Industry and SME with small lot production, dealing with:

- Increased flexibility
- Optimised resource usage
- Minimized planning & control efforts

The ARUM project will develop, assess and benchmark the solutions with two related use cases. The first is the production of aircraft equipment supplier (MGS) and the 2nd is a ship yard (FSG Flensburger Schiffswerft – EAB member).

Expected Scientific / Technology Impacts

Besides the economic the ARUM project will contribute to scientific & technology impacts:

- Opportunity to solve complex problems of resource management in manufacturing in real time.
- New methods and tools, models and algorithms for real time adaptive resource allocation, scheduling, optimization and controlling.
- Improved quality and efficiency of real time decision making in resource management for manufacturing:
    - Strategic - for long time horizon
    - Tactical (operative) - for short horizon

- State-of-the-art holonic architecture for designing and prototyping of new generation bio-inspired multi-agent systems for factories.
- Advanced SOA/ESB architecture of fully distributed for resource management of large-size manufacturers.
- Provide knowledge-based design and customization of resource management tools.
- The developed prototypes will showcase new technological and economical benefits of bio-inspired intelligent systems in real life case studies.
- The resulting platforms, systems and tools will provide much better service level, productivity and efficiency, adaptability and flexibility, scaleability, robustness and energy efficiency for manufacturers.

Impacts on Sustainability

ARUM focuses strongly on the new methods and tools for real time adaptive resource allocation, scheduling, optimization and controlling. The impact will be minimised resource consumption. Therefore ARUM will contribute to "Environmental friendliness" and "Economic growth" of the FoF PPP.

Contribution to Relevant Standards

ARUM will bring strategic opportunities to European companies and R&D institutes to participate to joint Standardization activities with the standardization bodies working on Industrial Agents, Ontologies and Communication and Interoperation Mechanisms.

- **Industrial Agents,** ARUM will work on standardisation of industrial Agents. This consists in two different perspectives: on one hand, the industrial agent-based solutions developed by ARUM should fulfil the current related industrial (manufacturing) standards, such as IEEE FIPA (Foundation for Intelligent Physical Agents), IEC 61499, ISA 95, ISA 88, etc. On the other hand, the task will drive the introduction of new standards or influence the specifications of the existing standards. As an example of this last perspective, ARUM foresees collaboration with the IEEE FIPA standardisation body, in order for the latter to accommodate some particular requirements of agent technologies to be used in industrial applications.
- **Ontologies,** ARUM will work on standardisation of ontologies: It will contribute to standardisation initiatives related to ontologies e.g. an obvious target standardisation body is the World Wide Web Consortium (W3C); ARUM will propose and actively support the creation of a new Community or Business Group within W3C, for the development of ontological models pertaining to ARUM's activities and knowledge domains.
- **Communication and Interoperation Mechanisms,** ARUM will be linked to a variety of initiatives and standardisation bodies, including:
  - Organization for the Advancement of Structured Information Standards (OASIS), e.g., the Technical Committees: Universal Business Language (UBL TC), Service-Oriented Architecture End-to-End Resource Planning (SOA-EERP TC), Semantic Execution Environment (SEE TC), Production Planning and Scheduling (PPS TC), Product Life Cycle Support (PLCS).
  - Wide Web Consortium (W3C), notably all the W3C initiatives related with service-orientation and semantic enhancement of service descriptions.

European dimension

The project takes into account the European strengths in the design of software intensive systems, with the best combination of mechatronics and software to build up highly adaptive

production systems. The project will develop synergies, coordination with the other European initiatives.

Impacts assigned to ARUM Concepts

The table below shows the impact and the end-user benefits for the envisaged ARUM solutions.

ARUM concept	Expected impact	End-User-Benefit
Ontology-based Network & Scenario Designer	• Lean & easy to use simulation system frontend for production models	Integration of domain-specific knowledge for manufacturing. Customization of intelligent solutions for scheduling, optimization and controlling. Standardization of ontologies for manufacturing.
Real Time Scheduling, Optimization and Controlling Tools	• Optimised resource management • Optimised resource usage • Short time to market	Increase of service level and efficiency of resources, reduce of delivery time, costs and risks
Holonic Multi-Agent p2p Architecture	• Increased robustness or existing & new planned production systems	Open, flexible, scalable, high performance, reliable systems for large-scale manufacturers. Standardization of protocols of systems interaction for manufacturing.
Real Time Simulations	• Agile manufacturing • Sustainable manufacturing • Better understanding of product design & manufacturing	Ongoing forecasting of risks and forming adaptation strategies
i-ESB Platform	• Lean & easy to implement ICT • Holistic ICT approach from manufacturing Systems (MES) to shop floor level	Decrease of time, costs and risks of complex systems design and implementation for manufacturing
SOA-based Enterprise Information Bus	• Lean & easy approach to integrate legacy systems (data, functionality) • Modular approach	Maximize the adaptability to given production set-ups
Integration across all hierarchies and along all manufacturing processes	• Optimal decision based on real-time holistic knowledge of production system	Maximize the decision-making basis Full data transparency

TABLE 11: ARUM CONCEPTS, IMPACTS & END-USER BENEFITS

Validation

To provide valid results, the participation of end-users in all phases of the study is mandatory.

ARUM will benefit from the end-user know-how and experience in a two-way approach:

a) ARUM results will frequently be analysed and supervised by a broad End-User Advisory Board.
b) End-Users are integrated in the consortium as WP-leaders or WP-partners and therefore directly influence the results of the WP´s. They are involved in nearly all relevant work packages (WP 1, 2, 7)

Within ARUM the End-User community represents a wide cross section of all EU-countries thus acting as a multiplier for ensuring that the study-results will be disseminated on European level.

Impact in – and outside the European Union

ARUM fully supports the EU policy on FoF laid down in [FACTORIES OF THE FUTURE PPP STRATEGIC MULTI-ANNUAL ROADMAP], concerning the main industrial needs and related R&D challenges:

- Sustainable manufacturing: the ARUM MAS solutions allow to readily improve and embrace other KPIs than financial cost-efficiency; energy-efficiency is an as much economic as ecological cost parameter that can be taken into account and put upfront if necessary. This will ensure that Europe but also worldwide manufacturing processes can meet the environmental constraints put up by international laws.
- ICT-enabled intelligent manufacturing: holonic approach as well as self-organised critical multi-agent system solutions to evolvable dynamic multi-project scheduling problems in ramp-up and small lot production management are truly a step up to the slow management approaches adopted by for instance BOEING.
- High performance manufacturing: again both the approach and the solutions are applicable to other domains than those foreseen by the project. ARUM approach applied to system and software development could certainly boost those areas too if the (human) developers or ingredients' of the artefacts monitored would be taken into the loop as such.
- Exploiting new materials through manufacturing: the knowledge processing MAS could exploit such insights and embody those to come up with alternative ramp-up designs and therewith also manufacturing (management) processes for not only aircraft manufacturing but also small lot production.

B 3.2 Plan for the use and dissemination of foreground

Dissemination

The goal of the dissemination is to create a structure able to disseminate the ARUM results during the project and beyond.

ARUM aims at developing new strategies and ICT for small lot series production and ramp-ups of complex and highly customized products. The project will open channels for an effective exchange of information, technologies and engineering experiences within the consortium network, in order to benefit from international developments in the addressed area of research (industry initiatives, funded and non-funded national and international research activities) (Internal Dissemination), and, in the meantime, the consortium will disseminate the project results and experiences to industrial communities (SME and Industry), to academic and research area, as well as to the generic audience that is interested in the project (External Dissemination) like Standardisation groups (T9.2).

Project results will be promoted and disseminated during the entire project, as an appropriate prerequisite for a successful exploitation at the end of the project. The dissemination is both a collective activity managed by the entire consortium and an individual set of actions handled by each single partner on a local level. All partners are aware that a broad dissemination of results carries a great importance and it is committed to allow access to the results achieved in the project to various kinds of audience and users: Information and research results will be considered to be public domain unless the consortium will decide otherwise.

The planned dissemination activities are outlined in the following, while individual partners' dissemination plans are listed in Annex 3.

General communication means

Already since the beginning of the project, the appropriate channels for communication with the mixed target audience of the project (manufacturing industry users, SME managers, researchers or SW developers, or other users, as well as the general public) will be established. The general means, targeting the broad audience, include the ARUM portal and the dissemination material.

The ARUM portal, as a principal channel of communication, will be early launched for creating initial awareness and interest for the ARUM activities, describing goals, stakes, technologies and the consortium itself. The public part of the portal will be used throughout the project for publishing the project results, such as public deliverables, white papers, publications, etc. The portal will also integrate a discussion forum, in order to focus attention on project communication or important issues and to gain feedback from third party organisations. In addition, the portal will contain a private area, providing access to the documents and code repositories, private discussion areas and any other internal procedure.

The general communication means will also include rich dissemination material, including project flyers and brochures (especially a brochure on use cases), white papers and presentations, a project poster; moreover, an electronic project newsletter and press releases (at least one per year) will be issued, underlying and diffusing the project results. Other means include presence in the mass media and domain specific communication channels of the industrial community (e.g., focused magazines), as well as multimedia material, such as movies highlighting the project results.

Since the target audience of the project is mixed (SME managers, researchers or SW developers, or general users from a manufacturing industry), the dissemination strategy of the consortium will use different available channels to reach this audience:

Dissemination towards technical and scientific audiences

The project's achievements will be communicated to the research community by the following means:

Publication in international peer-reviewed journals and magazines: All partners in the project will submit papers for publication. It is expected that the majority of these publications will be concentrated in the second and third years of the project (when concrete research results first become available). Target journals and magazines span across a variety of fields and disciplines (software engineering, multi-agent systems, semantic technologies and ontologies, industrial

informatics, business process management, security and data protection, etc.) and include (but are not limited to) the following:

- IEEE Transactions on Industrial Electronics (IEEE)
- IEEE Transactions on Industrial Informatics (IEEE)
- IEEE Transactions on Control Systems Technology (IEEE)
- Computers in Industry (Elsevier)
- Robotics and Computer-Integrated Manufacturing (Elsevier)
- International Journal of Production Research (Taylor & Francis)
- Simulation Modeling Practice and Theory (Elsevier)
- Journal of Management Information Systems (JMIS)
- Information and Management (Elsevier)
- Computers in Industry
- Computers and Operations Research
- Production Planning and Control
- Wirtschaftsinformatik" (WI, Gesellschaft für Informatik)
- "Wissensmanagement", Magazin für Führungskräfte (Lehnert e.K.)
- "Zeitschrift Führung und Organisation" (ZFO, Schäffer Poeschel)
- "Franken R. & Franken S., „Integriertes Wissens- und Innovationsmanagement",
- (Textbook, Gabler, 2nd edition planned for 2013/14)
- Journal of Intelligent Manufacturing (Springer)

Presence in international conferences and workshops: each partner will present the results of work carried out within the project at major international conferences and workshops. The corresponding list of target events is of course endless, certainly including the following:

- International Conference on Advanced Communications and Computation (IARIA / INFOCOMP, bi-annual conference)
- Industrial Applications of Holonic and Multi-Agent Systems (DEXA / HOLOMAS, bi-annual conference)
- Complex Systems: Control and Modelling Problems (CSCMP, RAS Samara, annual conference)
- International Conference on Self-Organization and Adaptation of Multi-agent and Grid Systems
- International Conference on Autonomous Agents and Multiagent Systems
- International ICT exposition - CEBIT
- International Conference on Database and Expert Systems Applications - DEXA
- Industrial Applications of Holonic and Multi-Agent Systems (HoloMAS)
- International Conference on Autonomous Agents and Multi-agents systems (AAMAS)
- Winter Simulation Conference
- International Conference on Industrial Applications of Holonic and Multi-Agent Systems
- IEEE International Conference on Emerging Technologies and Factory Automation (ETFA)
- International Conference on Control, Automation, Robotics and Vision Engineering (CARVE)
- IEEE International Conference on Industrial Informatics (INDIN)
- IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO)
- Annual Conference of the IEEE Industrial Electronics Society (IECON)
- IEEE International Symposium on Industrial Electronics (ISIE)

ARUM Workshops: during each year of the project, a Workshop with potential future users, industrial stakeholders, and other relevant parties will be organised for discussing results of validation and assessment of ARUM. To reach a broad but also specialised group of participants, the Workshops will be coupled to existing and well-known big conferences, dealing with ARUM relevant

issues. Representatives of the main ARUM target groups and experts important for ARUM will be invited to this Workshop. Primary outcomes of the Workshops will be: input to the requirements / scenarios and architecture (first year); input to the ongoing developments (second year); future-oriented evaluation of the ARUM systems (third year). These inputs will include suggestions on further RTD tasks and exploitation of the Living Lab infrastructure. The third Workshop will be more significant in size / approach to ensure that there is maximum exploitation and interaction potential.

Dissemination towards standardisation bodies and other related organisations

ARUM aims at becoming a project of high impact. In order to ensure that the resulting concepts will be further developed into products after the research stage and will foster European stakeholders to follow ARUM results, the project will establish strong liaisons with research, standardisation and decision making groups. Thus, ARUM partners will elaborate a common standardisation strategy, identifying relevant standardisation bodies and, for each of them, deciding on the appropriate level of participation (active contribution, active attendance, passive follow-up).

In that respect, a dedicated task within work package WP9 (T9.2) will, on the one hand, take care of ensuring that the project's decisions are aligned to current developments in relative standardisation bodies and, on the other hand, will pave the way for the wider adoption of its achievements and maximisation of its impact. As described in T9.2, the areas identified concern industrial agents, ontologies, mechanisms for communication and interoperation and industrial automation.

It must be stressed here that many ARUM partners are active members within national and international bodies for standardisation. Therefore, ARUM will benefit by the liaisons of its partners with organisations including the IEEE Industrial Electronics Society Technical Committee on Industrial Agents, IEEE Foundation for Intelligent Physical Agents (FIPA), World Wide Web Consortium (W3C), European Telecommunications Standards Institute (ETSI), Organization for the Advancement of Structured Information Standards (OASIS), etc.

Living Lab

To allow the promotion and dissemination of ARUM project results during but also and especially beyond the ARUM runtime the set-up of a Living Lab is envisaged. The ARUM Living Lab will comprise an environment devised for both internal and external use, enabling the use of ARUM software systems and functionalities. The concept concerns the deployment of a software platform infrastructure, reflecting the ARUM test bed and providing a selected set of the underlying functionalities to its users for experimentation.

At first, the Living Lab will serve the associated needs during the lifetime of the project; after the project end, the goal is to keep the ARUM Living Lab alive, in the form of a community-based system, administered and maintained by the academic partners of the project. Overall, the Living Lab will comprise an open environment, enabling experimentation across the lifecycle of ARUM, at the same time fostering and supporting participation of eligible external parties from FP7 and beyond for experimental dissemination and exploitation purposes.

Liaison and dissemination towards FP7 ICT

The ARUM project plans to adopt a high profile in the European ICT Program. In this activity, the members of the consortium will liaise with related EU projects, in order to ensure a higher scientific

and technological impact of the ARUM findings and solutions, as well as to foster exploration of possible synergies and complementarities. It is worthy to be mentioned here that all ARUM partners have great presence in the ICT Program, due to their participation in several and heterogeneous FP7 projects, including BonFIRE, COMMIUS, CONET, CONVERGENCE, DEMONS, FoFdation, GRACE, IRIS, MODUM, NEXOF-RA, SOA4All, etc. Intuitively, ARUM will establish channels of dissemination and knowledge exchange with running projects, while it will always be present with its results and focused demonstrations in the workshops organised by related EU projects. Additionally, ARUM partners will participate in EU events that relate with the project's scope and objectives, such as the EC consultation meetings.

Dissemination strategy:

The task T9.1 includes a sub-task specifically focusing on the definition of a dissemination plan, that will cover all dissemination elements and allocate specific responsibilities. The dissemination plan will be documented in a dedicated deliverable, detailing the expected dissemination and collaboration actions, their priorities, responsibilities and outcomes. While the plan will be delivered on month 6, it will essentially be a living document, updated every 6 months, to guide the project's awareness and interaction program. The dissemination plan's updates will be further documented in the forthcoming deliverables of T9.1, made available at the end of each project year, whereas the final report will provide a plan for the dissemination of ARUM after the end of the project.

Exploitation of project results

The ARUM exploitation plan has three main threads, notably technological, research and industrial. On one hand, there is the will among industrial partners to deploy and test the ARUM achievements for production control. The industry partners already use such systems and services, so the ARUM envisaged infrastructure is fully aligned to the underlying plans and objectives. Moreover, they look to the market for new solutions, as present approaches do not tackle current and future needs satisfactorily. So, as the ARUM consortium contains important European industrial stakeholders, the exploitation through each industry partner own organisation and production process is the obvious and natural way to benefit from the project results. Along this line, the project trials will give important feedback to shorten time-to-market and improve knowledge transfer.

On the other hand, in addition to the project objectives to pinpoint to a solution from which all European users could benefit, there are also plans to derive commercial products from the project research. Thus, the ARUM consortium has partners that constitute important technology stakeholders with their own exploitation and standardisation plans.

Of course, the consortium plans to make the project results available to the public domain to the extent possible, when this does not compromise each partner's exploitation plans. Related is the project's plan to contribute to standardisation bodies, which ensures that a significant part of project's work will be widely disseminated to foster its adoption, and that the infrastructure will interoperate with present and future developments in the area. The consortium has already discussed with industrial partners that are not part of the consortium due to resource shortage and that are willing and committed to participate in the standardisation initiatives that project plans to undertake.

Finally, universities and research institutes will be able to exploit the results in a manifold of ways, including high quality publications to journals, magazines, conferences and workshops and the

training of highly qualified engineers in Master and PhD programmes. Also, a desirable outcome would be the incubation of new SMEs through the academic partners; the consortium will actively encourage the creation of spin-off companies and the exploitation of any other opportunity for the commercialisation of the project findings.

Relevant factors that set the basis for a good exploitation of ARUM results are:

- Cooperation among strategic partners with complementary business roles, in order to align the requirements and architectural design.
- Experimental validation in lab trials, in order to get early feedback at the research stage. This will allow a fast time-to-market for ARUM-developed elements and components. This will be supported also by the ARUM Living Lab.
- Standardisation, as outlined above, in order to ensure that the resulting concepts will be further developed into products after the research stage and will foster European stakeholders to follow ARUM research results.
- Filing of patents when appropriate, in order to protect the innovative knowledge produced.

Management of knowledge and IP

Due to the innovation of the results expected to comprise the ARUM outcome, it is possible that partners will generate Intellectual Property that has to be protected through patents for their exploitation outside of the project with appropriate licensing. The project's handling of Intellectual Property Rights will be completely in line with Annex II of the FP7 Model Grant Agreement[8], of which all the ARUM participants are fully aware. The main aspects that are likely to arise are listed below:

- **Ownership of knowledge (Foreground IP)**: Knowledge shall be the property of the contractor carrying out the work leading to that knowledge. Where several contractors have jointly carried out work generating the knowledge and where their respective share of the work cannot be ascertained, they shall have joint ownership of such knowledge.
- **Protection of knowledge**: Where knowledge is capable of industrial or commercial application, its owner shall provide for its adequate and effective protection, in conformity with relevant legal provisions, including the Model Grant Agreement and the Consortium Agreement, and having due regard to the legitimate interests of the contractors concerned.
- **Access rights**: The general principles relating to access rights are the following.
    - Access rights (but no rights to source code) shall be granted to any of the other contractors upon written request. The granting of access rights may be made conditional on the conclusion of specific agreements aimed at ensuring that they are used only for the intended purpose, and of appropriate undertakings as to confidentiality.
    - Access rights to pre-existing know-how shall be granted provided that the contractor concerned is free to grant them, and has not explicitly excluded such access in the Consortium Agreement.

[8] FP7, Model grant agreement, Annex II – General Conditions, Version 2, 2008-10-02, available at http://cordis.europa.eu/fp7/calls-grant-agreement_en.html.

Nevertheless, the participants may conclude any agreement aimed at granting additional or more favourable access rights (including to third parties, e.g. affiliates), or at specifying the requirements applicable to access rights (without restricting them). Such provisions will be included in the Consortium Agreement that will be based on the Integrated Project Consortium Agreement (IPCA) and DEvelopment of a Simplified Consortium Agreement for FP7 (DESCA).

Furthermore, the IPR provisions of the Consortium Agreement will be particularised and concretised during the project, when the ARUM components and their dependencies will be more clear. In that respect, at the end of the first project year, a Deliverable (D9.4-1) will summarise the results of an internal workshop that will take place along with a plenary meeting. The aim of the workshop will be to identify the exploitable foreground project results and their dependencies, along with the associated beneficiaries and their rights as well as responsibilities, to determine the licensing strategy and to accordingly refine the IPR rules and provisions. In any case, the principles of fairness and proportionality will govern all IPR decisions.

Finally, the consortium is also aware of the services of the Commission's IPR Helpdesk[9]. The Project Coordinator will contact this support organisation to ensure that other EU projects and organisations worldwide are aware of any new pending patent.

B4. Ethics issues (if applicable)

The proposed project does not affect any of the ethical issues mentioned in the table below. The consortium is fully aware of the importance of ethical issues. Nevertheless, the Steering Committee in cooperation with the Quality Manager will raise and monitor these aspects regularly if deemed necessary to clarify any possible doubts along all (research) activities, demonstrations, protocols, data collection, presentation or transfer, etc.

ETHICS ISSUES TABLE

	Research on Human Embryo/ Foetus	YES	Page
*	Does the proposed research involve human Embryos?		
*	Does the proposed research involve human Foetal Tissues/ Cells?		
*	Does the proposed research involve human Embryonic Stem Cells (hESCs)?		
*	Does the proposed research on human Embryonic Stem Cells involve cells in culture?		
*	Does the proposed research on Human Embryonic Stem Cells involve the derivation of cells from Embryos?		

[9] Helpdesk on Intellectual Property Rights related issues in EU-funded projects, home page: http://www.ipr-helpdesk.org/home.html.

	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	x	

	Research on Humans	YES	Page
*	Does the proposed research involve children?		
*	Does the proposed research involve patients?		
*	Does the proposed research involve persons not able to give consent?		
*	Does the proposed research involve adult healthy volunteers?		
	Does the proposed research involve Human genetic material?		
	Does the proposed research involve Human biological samples?		
	Does the proposed research involve Human data collection?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	x	

	Privacy	YES	Page
	Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		
	Does the proposed research involve tracking the location or observation of people?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	x	

	Research on Animals	YES	Page
	Does the proposed research involve research on animals?		
	Are those animals transgenic small laboratory animals?		
	Are those animals transgenic farm animals?		
*	Are those animals non-human primates?		
	Are those animals cloned farm animals? I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	x	

	Research Involving ICP Countries	YES	Page
	Is the proposed research (or parts of it) going to take place in the one or more of the ICP countries?		
	Is any material used in the research (e.g. personal data, animal and /or human tissues samples, genetic material, live animal, etc) a) collected in any of the ICP countries?		
	b) Exported to any other country (including ICPC and EU Member States)?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	x	

	Dual Use	YES	Page
	Research having direct military use		
	Research having the potential for terrorist abuse		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	x	

B5. Gender aspects (optional)

There are no gender aspects to the scientific results and the technology to be developed with the ARUM project. However, there are gender aspects in terms of promoting an equal gender balance of researchers and gender within the project. All ARUM participants are highly motivated in promoting gender equality in the cultural and industrial areas covered by this proposal. Although project participants are not in the position to significantly affect the socio-cultural reasons that originate the gender bias, all participants recognize the importance of gender equality. They are committed to it in all aspects of the project's research and development activities.

Industrial partners like EADS for instance are very active in encouraging young women to pursue a technical career. A key element for achieving this is to make research and technical products tangible though demonstrations and workshops at universities and at production sites.

Participants will actively seek a gender-balanced participation in terms of integrating existing and employment of new staff, also in terms of inputs to user trials, workshops and user participation. Recruitment and advancement of women will be encouraged in an active way. This will be achieved by means of a merit-based open recruitment and staff review systems, monitoring of succession plans and reviews of success criteria in promotion.

At a different level, the project will use gender-neutral language and gender issues will be addressed in the end-user studies carried out in the project. The consortium of ARUM project is also well aware

of gender issues in science and technology (ref. “SEC (2005), Women and science: excellence and innovation – Gender equality in science”).